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ELF Communications System Ecological Monitoring Program: Michigan Bird Studies – Final Report

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13. ABSTRACT *(Maximum 200 words)*

The U.S. Navy has completed a program monitoring flora, fauna, and ecological relationships for possible effects from electromagnetic fields produced by its Extremely Low Frequency (ELF) Communications System. This report documents studies of the resident and migratory birds in Michigan.

Researchers from the University of Minnesota-Duluth (UMD) used a line-transect method to simultaneously census the avian community present in areas near (treatment) and far (reference) from the Michigan transmitter. Monthly censuses (May to September) were performed annually from 1986 through 1993. Data collected over the entire period of study were analyzed using repeated analysis of variance.

Study parameters included total species richness, species abundance, abundance of common bird species, and abundance of birds within selected guilds. Analyses showed a few statistically significant changes in the intersite relationship of parameters over time; however, the pattern of changes was not related to EM exposures. The number of significant changes was small, and not greater than that expected to occur by chance alone. Study results in Michigan are similar to those obtained by UMD for surveys performed near the Wisconsin transmitter. UMD researchers conclude no effects on avian ecology from operation of the ELF Communications System.

(ABSTRACT PREPARED BY IIT RESEARCH INSTITUTE)

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FOREWORD

This report has been prepared by researchers from the University of Minnesota-Duluth (UMD). It documents the results and conclusions of UMD's study of bird ecology for possible effects from exposure to electromagnetic fields produced by the U.S. Navy's ELF Communications System in Michigan. The study was funded by the Space and Naval Warfare Systems Command (SPAWAR) through contracts N00039-81-C-0357, N00039-84-C-0070, N00039-88-C-0065, and N00039-93-C-0001 to IIT Research Institute (IITRI). IITRI, a not-for-profit organization, managed the study through subcontract agreements with UMD.

This project was initiated in 1984 to monitor birds that were permanent residents in forests adjacent to ELF transmitters in both Michigan and Wisconsin. In 1986, the scope of the work was expanded to include birds migrating to, or through, the same areas used for monitoring of permanent residents. Wisconsin studies were concluded, as scheduled, in 1989 and UMD findings were presented in 1990 as a separate report. Michigan studies were concluded in 1993. The results and conclusions of the Michigan portion of the project are presented herein.

Since its inception, scientific peers have reviewed the technical quality of this study on an annual basis. In similar fashion, a draft of this report has been reviewed by peers with experience in bird ecology, statistics, and electromagnetics. UMD authors have considered, and addressed, peer critiques prior to submitting a revised manuscript to IITRI. Except for added prefatory and title pages, UMD's manuscript is here issued by IITRI on behalf of SPAWAR without further changes or editing by IITRI or SPAWAR.

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Respectfully submitted,
IIT RESEARCH INSTITUTE

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ELF COMMUNICATIONS SYSTEM ECOLOGICAL MONITORING PROGRAM:

BIRD SPECIES AND COMMUNITIES

FINAL REPORT: 1994

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SUMMARY

This investigation was designed to detect effects of electromagnetic (EM) fields produced by extremely low frequency (ELF) antenna systems on bird species breeding in or migrating through northern Wisconsin and northern Michigan. Specifically, we asked whether bird species richness and abundance differed between areas that were close to the antenna and those that were far enough away to be unaffected by EM fields produced by the antenna. We pursued this question at both the community and species level. Characteristics examined included total species richness and abundance, abundances of common bird species, and abundances of birds within selected guilds. Our monitoring program included bird censuses in both states over a five-month period from May to September, from 1986 onwards. Additional data were collected in August-September 1984 and in June 1985, in both states. Bird censuses were terminated in Wisconsin after 1989 and in 1993 in Michigan. Final results were reported previously for the Wisconsin study.

Interpretations of ELF EM field effects in the Michigan study reported here were based on significance of the interaction term in a repeated measures analysis of variance. For this analysis we were not interested in whether bird abundance varied annually (year effect), but whether bird abundance varied over time in the same manner in treatment and reference study areas. No significant interactions found at the community, species, or guild levels were consistent in any season. The number of significant interactions found at many levels of the analyses were not greater than the number expected by chance alone and therefore were unlikely attributable to EM fields produced by the ELF antenna.

ABSTRACT

This investigation was designed to isolate effects of electromagnetic (EM) fields produced by extremely low frequency (ELF) antenna systems on bird species breeding in or migrating through northern Wisconsin and northern Michigan. Our null hypothesis was that there were no differences in bird species richness and abundance between areas that were close to the antenna and areas that were far enough away to be unaffected by the antenna. We pursued this question at both the community and species level. Characteristics examined include total species richness and abundance, abundances of common bird species, and abundances of birds within selected foraging, nesting, migration, and habitat guilds. Our monitoring program included bird censuses over a five-month period from May to September (1986-1993). Additional data were collected in both states during August and September of 1984 and during June of 1985. Research in Wisconsin was completed in 1989 (Hanowski et al. 1991) and in Michigan in 1993.

The Michigan transmitter began 150-amp tuning and testing intermittently in the first part of May 1989. On 14 May, the transmitter began continuous 150-amp operation for 16 hrs/day on weekdays and all day on weekends. On 7 October 1989, the Michigan transmitter began continuous operation at full power. Because of the manner in which the antenna was tested prior to becoming fully operational, we assigned bird census period and year(s) into levels of EM field exposure based on level (amps) at which the antenna was operated and the number of hours it was operated. Three exposure levels were identified for the spring migration and breeding season: 1986, 1987, 1988 = low amps and low hours, 1989 = high amps and low hours, and 1990, 1991, 1992, 1993 = operational (high amps and high hours). A fourth exposure period was identified for the fall migration period. Here we specified that 1988 was a medium-amp and low-hour exposure period.

To investigate possible effects of ELF EM fields, we analyzed changes in species abundances over time on treatment and reference segments using a repeated measures ANOVA. The repeated measures ANOVA incorporates data from all years and compares changes in abundance in bird parameters over time throughout the different EM field exposure periods. For this test, a significant interaction would indicate that changes in bird abundance over time were not equal in treatment and reference areas.

We recorded a total of 52,175 birds during the entire study, 25,401 on treatment and 26,774 on reference segments. A total of 140 species were observed over all years and seasons; 21 were counted only on reference and 5 only on treatment transects. No species observed either exclusively in reference or treatment areas was common in the study area in any season or year (from 1 to 7 total observations).

Numbers of individuals and species observed in all seasons have fluctuated annually. Annual variation in abundance was greatest during both migration periods, the time when birds are moving through the study areas. A significant interaction ($P < 0.03$) was found for both numbers of species and individuals during the fall migration period and for number of species during the spring migration period. Numbers of individuals and species observed during spring migration reflected patterns found during the breeding season; numbers were consistently higher in reference than in treatment study areas in all years. Although a significant interaction in number of species observed in the spring migration was found between reference and treatment study areas, the trend has been for numbers observed to converge over time. Numbers of species and individuals observed in reference areas during fall migration have fluctuated more widely than numbers observed in the treatment areas. Examination of abundance patterns over time for these community patterns did not indicate that changes were due to electromagnetic fields.

Three of nine tests of migration guild parameters (three types X three seasons) indicated a significant interaction ($P < 0.05$) in the repeated measure ANOVA. No consistent patterns emerged for any migration group across seasons nor were there patterns of change among treatment or reference areas over years that would suggest that differences detected were due to electromagnetic field exposure. For example, changes in numbers of long-distant migrants over years was not the same ($P < 0.01$) on reference and treatment transects during spring migration. A significant interaction ($P < 0.04$) was found for permanent resident species during the breeding season, and during fall migration, a difference ($P < 0.04$) in number of short-distant migrants.

Examination of birds within five feeding guilds over three seasons (15 total tests) indicated only two significant interactions in changes in numbers over time within treatment and reference areas. Numbers of foliage insectivores have declined overall in both control and treatment areas during migration but have fluctuated more widely in treatment areas. Number of bark insect foraging species also showed a significant interaction ($P < 0.03$) in numbers over time during the breeding season, but in contrast overall numbers have increased in both reference and treatment areas from 1986 to 1993. Neither of these significant differences could be attributed to electromagnetic fields.

A small percentage of significant tests among nesting guilds was found (2 of 18). Number of birds that nest in cavities was consistently higher in reference than treatment areas over all years, but numbers in treatment areas fluctuated more over years, especially from 1990 to 1991. Overall numbers, however, have increased from 1986 to 1993 in both reference and treatment areas during the breeding season. Number of ground nesting birds observed during fall migration have declined in both reference and treatment areas over time, but numbers on treatment transects have fluctuated more widely during this time period than numbers counted in reference areas. Examination of abundance patterns over time for these groups did not suggest that changes were due to electromagnetic fields.

One of 18 tests among habitat guilds indicated that changes in abundance over time in treatment and reference areas differed. For this guild group, numbers of birds that prefer mixed forests showed a significant interaction ($P < 0.01$) during spring migration. Overall, numbers have declined in both treatment and reference areas from 1986 to 1993 but the magnitude of declines have been higher in reference than treatment areas. Again, this pattern does not suggest a negative electromagnetic field exposure effect.

Three of 38 species (8%) species tested in the spring migration season indicated a significant interaction in abundance over years ($P < 0.05$) between reference and treatment study areas. Patterns of species abundance over years in treatment and reference areas for these three species showed two different patterns. For one species, the Black-and-white Warbler, abundance in treatment and reference areas have tracked fairly well with treatment transects showing a slightly larger change in abundance over time. Abundance patterns for two species, the Rose-breasted Grosbeak and Song Sparrow varied considerably but not consistently in treatment and reference areas over years. For these species, however, abundance declined more in reference than in treatment areas from pre to post-impact years. Patterns of change in these species abundance over time do not indicate a negative effect of exposure to electromagnetic fields.

Three of 54 (5%) species tested indicated that change in abundance over years was significantly ($P < 0.05$) different between reference and treatment study areas in the breeding season. Patterns of changes in abundance for all three species; Red-breasted Nuthatch, Great Crested Flycatcher, and Chipping Sparrow have been highly variable in both treatment and reference areas over years. However, relative abundance patterns in pre-treatment years and in post-treatment years on treatment and reference areas have been fairly consistent. This suggests that electromagnetic fields had no negative impact on these bird species.

Six percent (2 of 33) species tested in the fall migration period indicated a significant difference ($P < 0.05$) in abundance over years in treatment and reference study areas. Abundance patterns for these species, Golden-crowned Kinglet and American Woodcock,have declined more overall in treatment than reference study areas over years. The greatest decline in number for both species occurred prior to the antenna becoming fully operational. Patterns of change on treatment and reference transects abundance patterns have been similar since 1990.

No consistent patterns were evident to demonstrate that changes in bird abundance differ between treatment relative to reference segments in Michigan after the antenna became operational. No significant interactions found at the community or species level were consistent in subsequent seasons. In addition, interactions in guild or individual species abundance patterns that existed between treatment and reference areas in any season were not repeated in subsequent seasons. Number of significant interactions found at many levels of the analyses were not greater than the number expected by chance alone and were unlikely attributable to electromagnetic fields.

INTRODUCTION

Effects of exposure to extremely low frequency (ELF) electromagnetic (EM) fields (other than the earth's), and the mechanisms by which bird behavior, reproduction, or migration may be affected by exposure are largely unknown (National Academy of Sciences 1977; Lee et al. 1979). Some birds are known to be able to detect slight changes in magnetic fields (Semm and Beason 1990) and use the earth's magnetic field for orientation during migration (Wiltschko and Wiltschko 1988). An ability to detect ELF electric or magnetic fields does not, however, imply an adverse biological effect (American Institute of Biological Sciences 1985). Data obtained from laboratory studies suggest that ELF EM fields may affect animals either by covert biochemical or physiological changes that may alter chances of survival (e.g., mutations, changes in hormone or enzyme levels), or overt behavioral responses resulting from detection and reaction to ELF EM fields (American Institute of Biological Sciences 1985). Most previous field investigations have attempted to document overt behavioral responses resulting from the combined effects of habitat alteration and EM fields and to determine how those responses may affect the structure and composition of bird communities (Anderson et al. 1977; Anderson 1979; Meyers and Provost 1979; Stapleton and Kiviat 1979; Bell 1980; Bramble et al. 1984; Niemi and Hanowski 1984). Others have focused on effects of rights-of-way (ROW) (Chasko and Gates 1982; Kroodsma 1982), on collision with lines and structures (Avery et al. 1980), and on audible noise generated by a transmission line (Lee and Griffith 1978). To our knowledge, our recently completed study on effects on birds of EM fields produced by the US Navy's ELF transmission facility in Wisconsin (Hanowski et al. 1991) was the first that attempted to separate effects of EM fields on bird species and communities from effects due to habitat changes along the ROW. That study produced no convincing evidence that birds were either attracted to or repelled by EM fields produced by the antenna.

Our investigations in Michigan and Wisconsin (Hanowski et al. 1993) were designed to isolate effects of EM fields produced by ELF antenna systems on bird species breeding in or migrating through northern Wisconsin and northern Michigan. Our goal was to determine if distribution and abundance of bird species differed between areas that were close to the antenna and those that were far enough away to be unaffected by EM fields produced by the antenna. Our study included periods during spring migration (May), breeding season (June and July), and fall migration (August and September). Potential effects of the ELF antenna on birds may vary among seasons. During migration, birds may be present on study areas for only brief periods. Conversely, breeding birds remain on territories longer (1-3 months), increasing their exposure to EM fields.

To assess effects of the ELF antenna on bird communities we can either: (1) compare the affected area (treatment) with a similar reference area; or (2) conduct a before-and-after study on both reference and treatment plots. The former approach was used in Wisconsin because the antenna already was in operation at the start of our study. Research in Michigan was, in contrast, initiated before the antenna began full operation. By following changes in bird numbers over time on areas affected by the

antenna and on unaffected areas, we can separate effects of the antenna on birds from effects of more regional variables (e.g., annual variation in rainfall) and from effects arising from differences in vegetation structure between reference and treatment areas. In the following we summarize our research activities in Michigan where data have been collected for eight years during the spring and fall migration and breeding seasons.

METHODS

Study areas. Starting points and direction of travel along five treatment and five reference transects were randomly determined (see Hanowski et al. 1990) (Figure 1). Each 4.35 km transect was divided into eight 500 m segments each separated by a 50 m buffer (total N = 40 in each reference and treatment group). The 50 m buffer was included to assure that adjacent segments were independent.

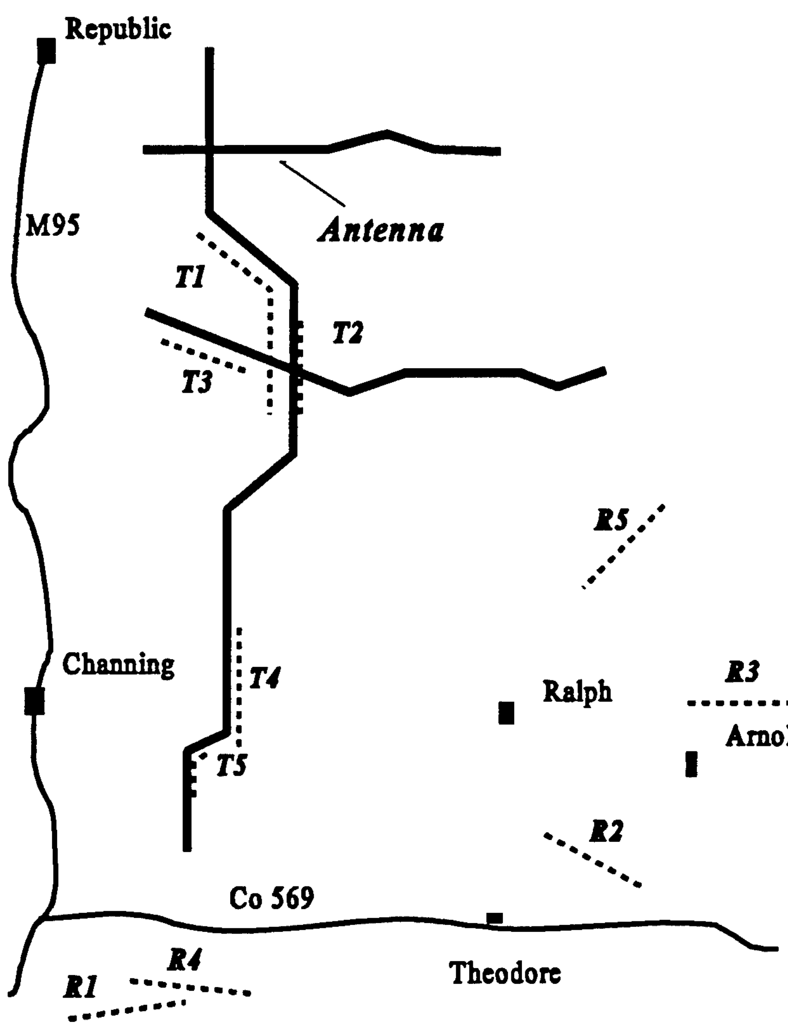

Figure 1. Location of reference (R1 to R5) and treatment (T1 to T5) transects in Michigan.

Breeding and migrating birds

Spatial autocorrelation tests (Moran's I statistic; Sokal and Oden 1978) indicated that a 50 m buffer was sufficient for considering each 500 m segment as an independent experimental unit (Hanowski et al. 1990). Treatment transects were placed 125 m away from and parallel to the antenna ROW to reduce possible edge effects; the ROW was not sampled. Reference transects were located more than 10 km from the antenna where EM field magnitudes were at least an order of magnitude lower than the treatment sites.

Some 500 m transect segments in Michigan have been partially logged since this study started. The Michigan Department of Natural Resources agreed to delay most additional logging until 1994. Analyses of annual variation in bird community composition revealed that segments logged <20% of their total length showed no greater difference in bird populations between years than did unlogged sites. Segments that were logged > 20% of their length showed significantly greater differences in bird species composition between years than did unlogged segments. Consequently, our analyses of bird distribution patterns between years omits segments logged over more than 20% of their length. Sample sizes used in final analyses were 36 reference transects and 33 treatment transects.

EM Fields. EM fields were measured at the beginning, at some intermediate points, and at the end of each 500 m segment by IIT Research Institute engineers (Haradem et al. 1989). EM fields produced by the ELF communication system include: (1) essentially identical air and earth magnetic fields generated by the electrical current in the antenna and ground terminals; (2) an electric field in the earth that is the sum of the fields induced by the magnetic field and the current from the buried ground terminals; and (3) an electric field in the air that is produced as a result of the difference in potential between the antenna element and the earth (Haradem et al. 1989). All possible reference-treatment pairs (each combination of individual 500 m transects) were required to meet EM exposure criteria that assured that 76 Hz EM fields at treatment sites were at least an order of magnitude higher than those at reference sites. In addition, to isolate effects of 76 Hz fields from those of 60 Hz fields (i.e., regular power distribution utilities), 76 Hz field intensities at treatment sites had to be at least an order of magnitude greater than EM fields produced by 60 Hz powerlines at both treatment and reference sites. Moreover, 60 Hz fields between reference and treatment sites could not be significantly different (Haradem et al. 1989).

We assigned bird census period and year(s) into three levels of EM exposure based on levels at which the antenna was operated (Figure 2) and the number of hours it was operated (Figure 3). Three exposure levels were identified for the spring migration and breeding seasons: 1986, 1987, 1988 = low amps and low hours, 1989 = high amps and low hours, and 1990, 1991, 1992, 1993 = operational phase. A fourth exposure period was identified for the fall migration season. Here we specified 1988 as a medium-amp and low-hour exposure period. We also calculated the number of times the antenna was turned on and off in each season and year (Figure 4).

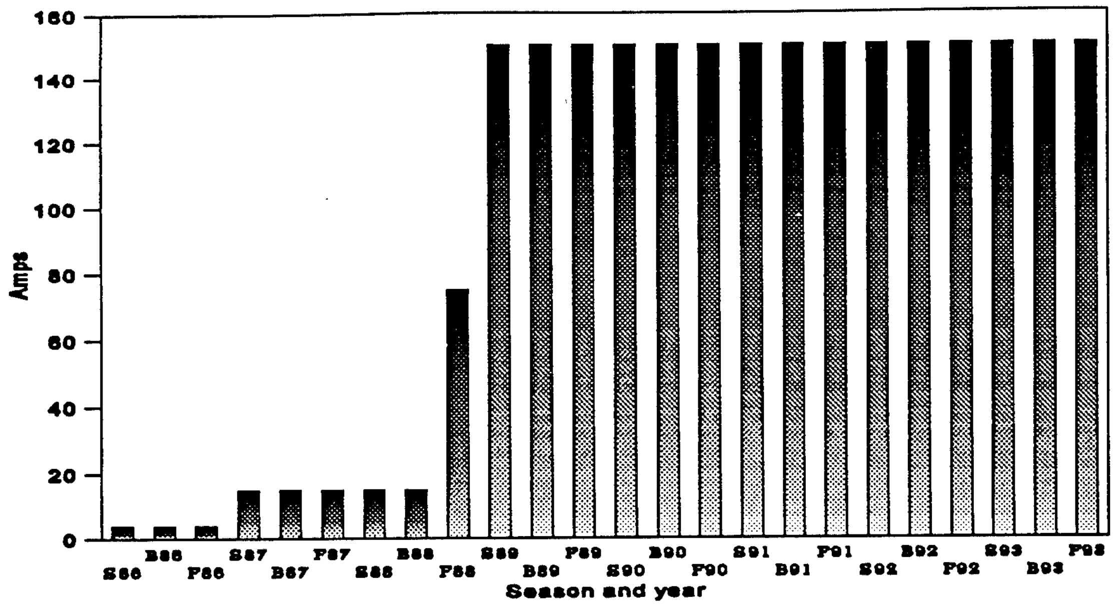

Figure 2. Number of amps the antenna was operated during spring (S), breeding (B), and fall migration (F) periods from 1986 to 1993.

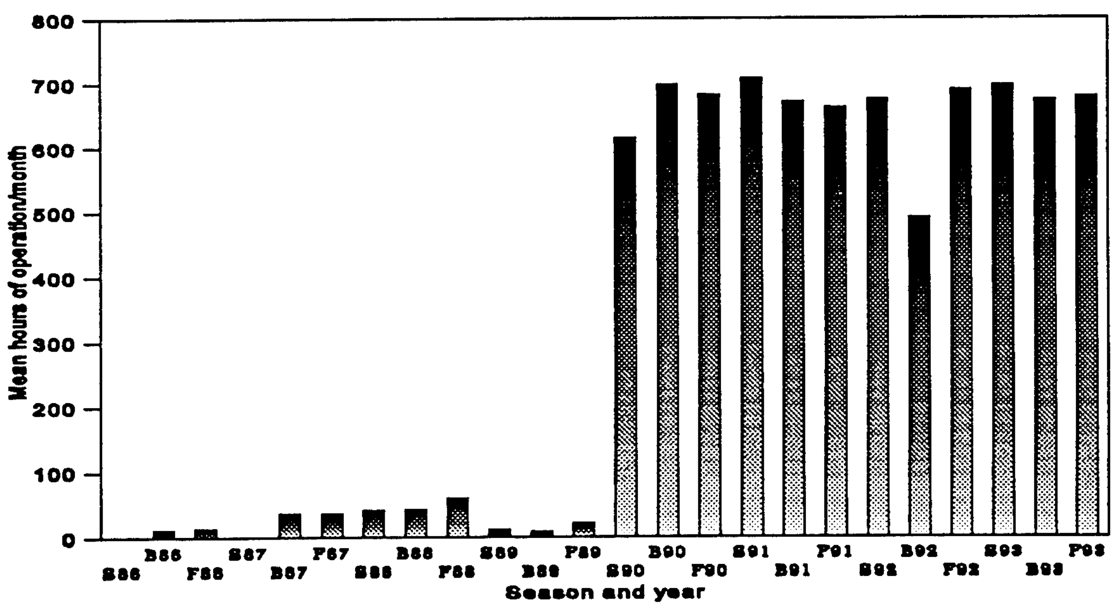

Figure 3. Mean number of hours the antenna was operated during spring (S), breeding (B), and fall migration (F) periods from 1986 to 1993.

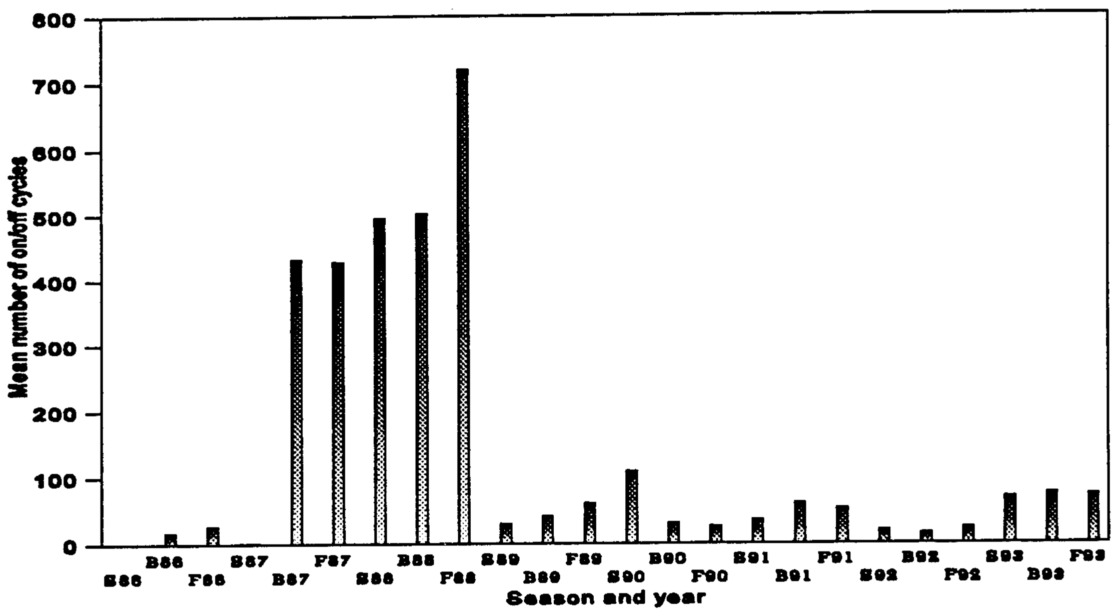

Figure 4. Mean number of times the antenna was cycled during spring (S), breeding (B), and fall migration (F) periods from 1986 to 1993.

Bird counts. We counted birds on line transects (Järvinen and Väisänen 1975; Hanowski et al. 1990) five times each year (May through September 1986-1993). Censusing was completed between 0.5 hr before and 4.5 hrs after sunrise on days with little wind (< 15 km/hr) and no precipitation. Reference and treatment transects were sampled simultaneously by each of two observers to control for possible temporal variation in bird activity between areas. All observers were experienced in the identification of birds by sight and sound; training sessions were conducted prior to censusing to standardize recording methods. Each observer walked at a rate of 1 km/hr and recorded the identity for each bird detected and its location along and perpendicular to the transect (up to 100 m from the transect center line). Birds flying over the canopy were not counted.

We used the maximum number of individuals for each species observed during two breeding (June and July) and two fall migration counts (August and September) along each transect in all data analyses instead of attempting to calculate a density value for each species. We considered the May census as spring migration. With this method we attempted to record the maximum number of breeding or migrating individuals to partially control for annual differences in phenology of breeding or migration seasons. For example, if two Ovenbirds were counted on one transect in

June and three were observed in July, we used three in the data analysis for that transect segment for the breeding period.

Density could be calculated with a variety of formulae (Emlen 1971, 1977; Järvinen and Väisänen 1975; Burnham et al. 1981; Buckland 1985), but there are several assumptions that must be met before these methods can be used. A critical assumption is that distances are measured accurately. These measurements are difficult to obtain when birds are heard but not seen; most bird recorded during counts were only heard. Without accurate distance estimates these methods do not provide valid density estimates. Hence, density estimates may provide an index that may be no better than the actual counts (Wilson and Bart 1985). In addition, absolute density calculations are not needed in most investigations, especially when comparisons of "relative density" are less costly and allow the investigator to meet the objectives of the experiment (see Verner 1985). Here, we assumed that number of birds recorded was related to bird density in an area (see Raphael 1987) and that bird detectability was similar between reference and treatment areas.

Bird guilds. We classified each species by (1) nesting area, (2) food or foraging type, (3) breeding habitat preference, and (4) migration strategy (Appendix 1), using published sources (see Hanowski et al. 1993) and personal observations. Individual statistical tests were used to compare numbers of individuals within different guild groups between treatment and reference study areas.

Statistical analyses. We used a repeated measures analysis of variance (ANOVA) to test for differences in bird abundance between reference and treatment transects within each season. This procedure is relevant when several measurements (e.g., multiple years) are taken on each experimental unit and the measurements are correlated. The test is essentially a multivariate technique which accounts for correlations among the dependent variables while testing for treatment effects (Freund et al. 1986). A two-factor repeated measures ANOVA was done. The between-subject factor was area (treatment versus reference), the within-subject factor was year (1986 to 1993), and the dependent variable was bird abundance. The two-way interaction of area-by-year was also included in the model. Multiple contrasts reflecting years of different levels of EM exposure (3 for the spring migration and breeding seasons and 6 for the fall migration period) were done for any parameter that showed an overall treatment-by-year interaction (see page 5 for definition of exposure periods).

Data were examined separately for each species (in each season), provided that at least five individuals were observed in any one year. At total of 54 species were tested in the breeding season, 38 in the spring migration period, and 33 species during fall migration. Because of differences in detectability of birds in different seasons, no between season comparisons were completed.

Annual differences and treatment effects were also examined for each season with repeated measures ANOVA for total number of species observed in a 500 m segment and total number of individuals observed in a 500 m segment. The same

model used for individual species (two-factor repeated measures ANOVA, see above) was used for these tests. The only difference was that we used a univariate test for these tests, not the multivariate test that we used for individual species. We did this because we were able to meet assumptions of the univariate test for these variables, and when assumptions are met, it is more powerful than the multivariate test (Freund et al. 1986). All variables were examined for normality and homoscedasticity of variances prior to statistical analyses (Sokal and Rohlf 1981) and were transformed when necessary (e.g., logarithmic, square root) to reduce skewness, kurtosis, and heterogeneity of variances.

One assumption of repeated measures ANOVA (for multivariate test) is that dependent variables in the model have a multivariate normal distribution with a common covariance matrix across the between-subject effects (treatments) (Freund et al. 1986). However, if groups have relatively equal sample sizes, the analysis is insensitive to departures from this assumption (Hand and Taylor 1987). In addition, with the exception of independent sampling, assumptions become less important for larger sample sizes. We have used a large and almost equal sample size in our analyses; therefore, we conducted the repeated measures ANOVA (only the multivariate test) on some species regardless of whether the homogeneity assumption was met (see LaTour and Miniard 1983). We do not report results from tests where the univariate test was significant if the sphericity assumption was violated.

We used SOLO power analysis (BMDP 1992) to calculate the power of a univariate repeated measures analysis of variance (treatment-by-year interaction). Coefficients of variation (CV's) were first calculated for each community, guild, and individual species parameters in each season. We then computed the power for the range of CV's for three levels of change (a 10%, 25%, and 50% difference) in the parameter of interest.

RESULTS

The repeated measures analyses includes tests for differences among years, among treatments, and an interaction term. Interpretations of ELF effects in parameters tested here were based on significance of the interaction term. For this analysis we were not interested in whether bird abundance varied annually (year effect) or whether treatment and reference sites were different (treatment effect). Because we used a before-and-after design in this study, we were interested in determining whether bird abundance varied over time equally in treatment and reference areas. A significant interaction term (interaction effect) would indicate that a change in abundance pattern on treatment and reference areas was not the same over time (e.g., before-and-after the antenna was operated). To analyze potential differences in bird responses to exposure duration (amount of time the antenna was operated) and strength (number of amps), multiple contrasts were conducted for those bird parameters that showed a significant treatment-by-year interaction.

Electromagnetic fields. Electric fields (76 Hz) measured in the earth were 0.99 mV/m (range 0.02 - 2.7 mV/m) on reference and 62.8 mV/m (range 21 - 112 mV/m) on treatment sites. Mean 76 Hz magnetic flux densities were 0.01 mG on reference (range 0.001 - 0.07 mG) and 2.9 mG on treatment sites (range 0.9 - 15.0 mG). Electric fields in the air (76 Hz) were not measurable on reference sites and were 0.16 mV/m on treatment sites (range 0.02 - 0.13 mV/m) (Haradem et al. 1993).

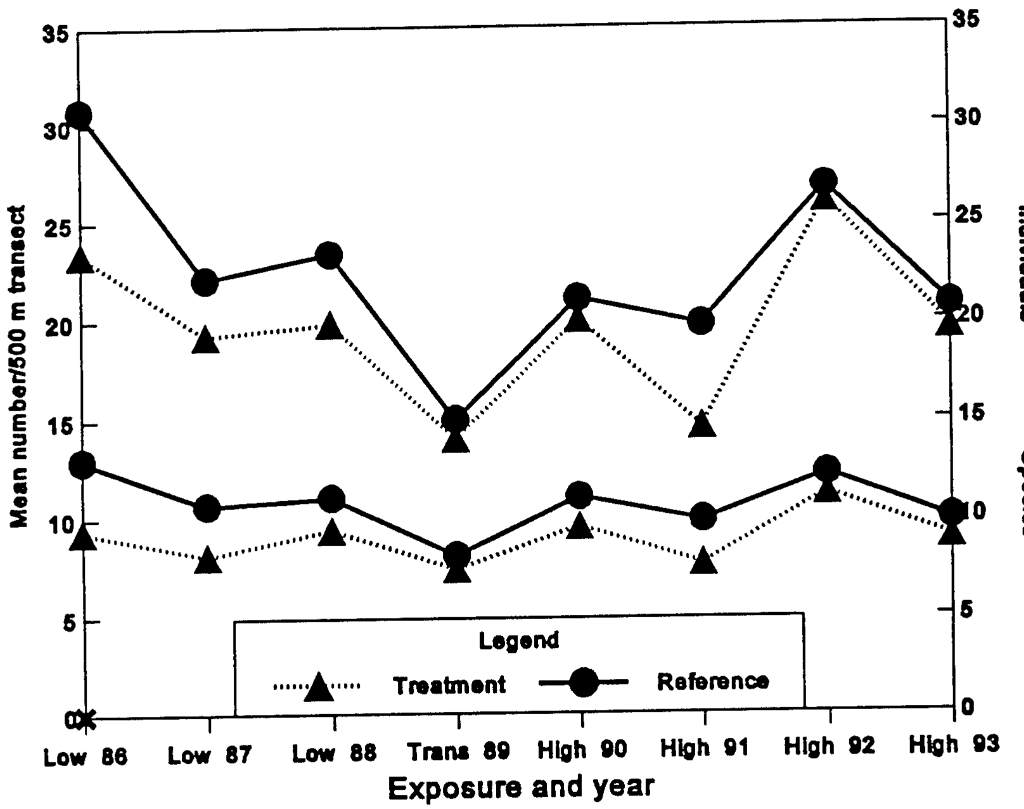

Figure 5. Mean number/500 m transect of individuals (top) and species (bottom) observed in treatment or reference study areas from 1986 to 1993 during the spring migration period.

Community parameters. We recorded a total of 52,175 birds during the entire study, 25,401 on treatment and 26,774 on reference segments (Table 1, p 9). A total of 140 species were observed over all years and seasons; 21 were counted only on reference transects and 5 only on treatment transects (Appendix 2, 3, 4). Most species counted only on reference transects were those associated with small ponds or riparian areas (e.g., Great Blue Heron, Pied-billed Grebe, Wilson's Warbler (scientific names are in Appendix 1). Species observed either exclusively in reference or treatment areas were not common in the study area in any season or year (from 1 to 7 total observations in all years together).

Table 1. Total numbers of individuals and species observed in treatment (T) and reference (R) transects in Michigan, 1986-1993. A combined species total for treatment and reference segments is in parentheses.

Parameter	Year	Spring Migration		Breeding		Fall Migration	
		T	R	T	R	T	R
Total individuals	1986	949	1210	1604	1734	682	978
	1987	775	888	1776	1850	1129	936
	1988	815	939	1494	1538	882	882
	1989	570	607	1550	1573	1122	838
	1990	847	858	1324	1378	635	741
	1991	578	778	1371	1557	1001	901
	1992	1045	1060	1638	1700	741	737
	1993	795	836	1412	1516	666	739
Total no. species	1986	54 (76)	69	73 (91)	81	63 (70)	59
	1987	50 (69)	62	80 (95)	86	69 (81)	64
	1988	53 (68)	56	82 (104)	87	63 (81)	67
	1989	44 (62)	46	76 (93)	81	70 (80)	59
	1990	65 (80)	65	79 (90)	76	52 (68)	55
	1991	55 (76)	62	75 (90)	80	61 (78)	61
	1992	66 (83)	69	76 (89)	74	57 (70)	57
	1993	54 (73)	59	72 (87)	76	53 (69)	51

Numbers of individuals and species observed in all seasons have fluctuated annually. Annual variation in abundance was greatest during both migration periods, the time when birds are moving through the study areas (Figures 5, 6, 7: pgs 8, 10, 12). A significant interaction ($P < 0.03$) was found for both numbers of species and individuals during the fall migration period (Table 2, p 11). Although numbers observed in reference areas during fall migration have been fairly consistent over time, numbers observed on treatment transects have varied dramatically, being higher than reference areas in three years, lower in three years, and equal to reference in one year. An overall downward trend in numbers is evident in both areas. However, reference areas have shown a more negative trend than treatment areas (Figure 7).

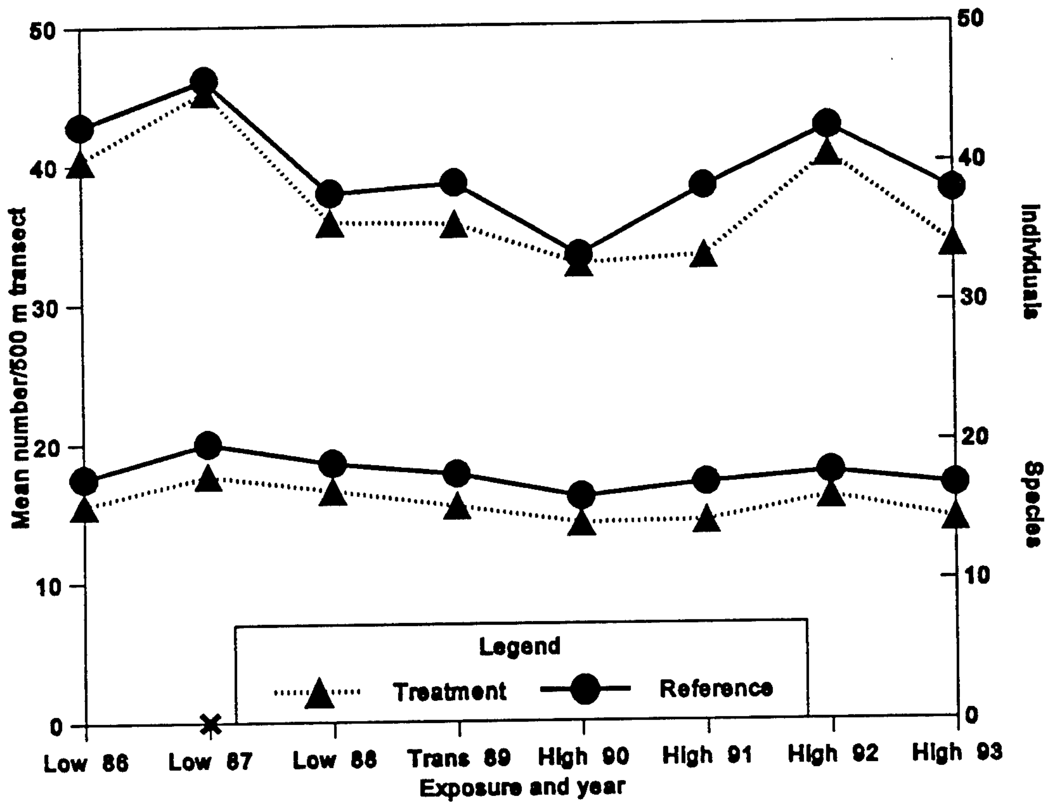

Figure 6. Number of individuals (top) and species observed/500 m transect on treatment and reference transects during the breeding season 1986 to 1993.

Numbers of individuals and species observed during spring migration were consistently higher in reference than in treatment study areas in all years (Figure 5). Although a significant interaction in number of species observed in the spring migration was found between reference and treatment study areas, the trend has been for number of species observed to converge over time (see Figure 5).

Table 2. Mean number (per 500 m transect) and standard error of total number of species and individuals. A significant interaction (repeated measures ANOVA) was found between reference and treatment for numbers of species in the spring and fall migration periods and for number of individuals in the fall migration period.

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Parameter	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Total individuals	1986	23.39	1.39	30.78	1.37	40.33	1.82	42.83	1.93	16.67	1.58	23.92	2.60
	1987	19.27	1.60	22.11	1.71	45.30	2.30	46.17	2.18	27.00	2.30	23.53	1.81
	1988	19.85	1.56	23.39	1.36	35.82	1.90	37.94	1.71	19.21	1.87	22.06	1.96
	1989	14.03	1.57	15.00	1.21	35.67	1.92	38.64	1.67	27.24	3.01	21.33	2.03
	1990	20.06	1.92	21.11	1.22	32.79	1.97	33.39	1.59	13.58	1.00	18.22	1.31
	1991	14.61	1.54	19.81	1.66	33.33	1.80	38.33	1.59	25.12	2.74	22.36	1.11
	1992	26.03	1.75	26.78	1.79	40.61	1.69	42.58	1.87	18.15	1.53	18.25	1.32
	1993	19.61	1.47	20.75	1.27	34.03	1.78	37.97	1.50	15.91	1.32	18.42	1.07
Total no. species	1986	9.36	0.49	12.97	0.61	15.58	0.73	17.53	0.83	7.42	0.66	9.33	0.65
	1987	8.09	0.59	10.67	0.58	17.70	0.96	20.03	0.93	10.36	0.79	9.92	0.69
	1988	9.42	0.58	11.06	0.59	16.58	0.85	18.56	0.81	8.24	0.53	9.25	0.73
	1989	7.42	0.67	8.11	0.55	15.45	0.73	17.75	0.90	10.18	0.87	9.33	0.54
	1990	9.58	0.76	11.08	0.62	14.18	0.69	16.08	0.67	7.12	0.50	8.89	0.55
	1991	7.67	0.76	9.89	0.73	14.33	0.79	17.06	0.78	8.91	0.74	10.17	0.49
	1992	11.24	0.59	12.22	0.75	16.06	0.76	17.83	0.76	8.03	0.63	8.03	0.50
	1993	9.00	0.59	9.92	0.57	14.36	0.78	16.83	0.76	6.58	0.57	7.25	0.46

Guild parameters. Examination of birds within five feeding guilds over three seasons (15 total tests) indicated only two significant interactions in changes in numbers over time within treatment and reference areas (Table 3, p 13). Numbers of foliage insectivores have declined overall in both reference and treatment areas during fall migration, but have fluctuated more widely in treatment areas (Table 3, also Figure 18, p 33). Overall declines have been greater in magnitude on reference than on treatment transects over the years. Two contrasts were significant for this group, one between the low and transitional period and one between the transitional and high exposure periods. Number of bark insect foraging species also showed a significant interaction ($P < 0.03$) in numbers over time during the breeding season, but overall numbers have increased in both reference and treatment areas from 1986 to 1993 (Table 3; Figure 19, p 34). Contrasts for this measure indicated a difference between the low and high exposure periods.

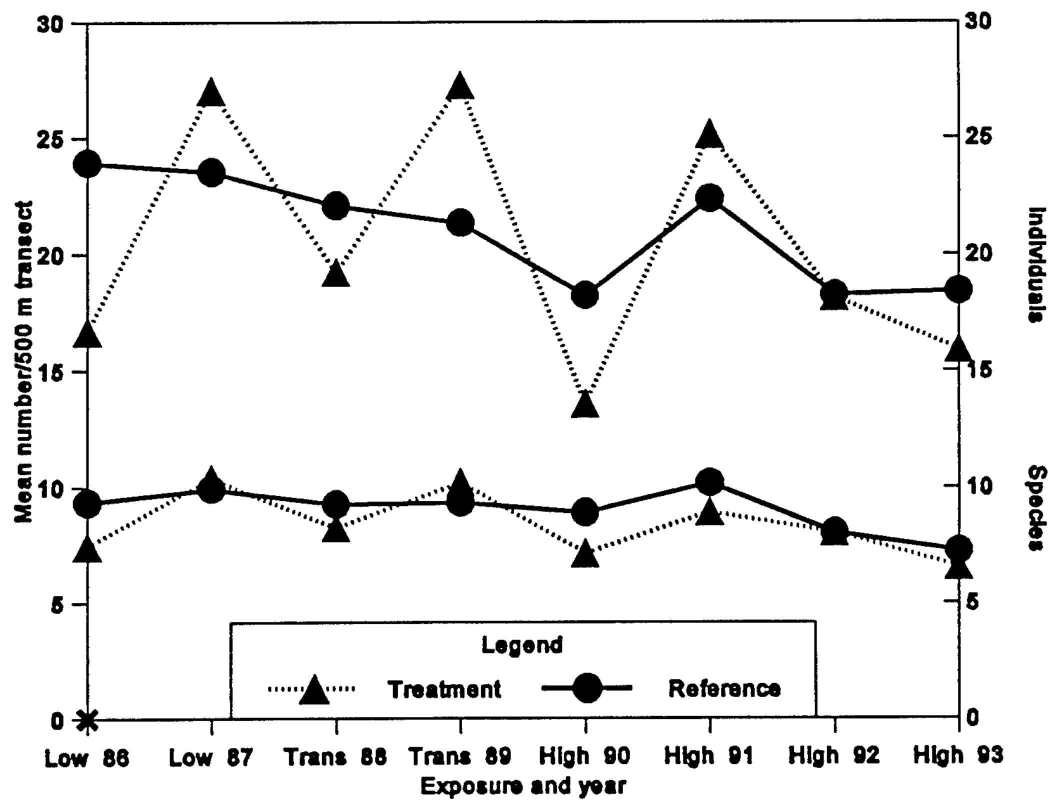

Figure 7. Number of individuals (top) and species observed/500 m transect on treatment and reference transects during the fall migration period 1986 to 1993.

Table 3. Mean number (per 500 m transect) and standard error of individuals in habitat, nest, migration, and foraging guilds that showed a significant interaction in abundance over years (repeated measures ANOVA) between treatment and reference. Superscript letters indicate season where a difference was detected (S=spring migration, B=breeding, F=fall migration).

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Guild	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Foliage insects[F]	1986	13.27	1.09	16.44	0.72	21.88	0.97	23.03	1.01	6.79	0.82	10.94	2.19
	1987	10.39	1.15	10.42	1.02	24.55	1.44	22.97	1.07	10.58	1.38	8.92	1.02
	1988	8.00	0.94	9.11	0.90	20.06	1.02	19.58	1.12	7.18	0.91	8.72	0.86
	1989	5.48	0.76	5.39	0.59	19.30	1.05	20.72	0.94	10.55	1.11	8.94	1.06
	1990	11.15	1.15	10.42	0.76	17.97	1.09	18.86	1.09	6.24	0.67	8.28	0.88
	1991	8.39	1.02	10.22	1.24	20.15	1.04	22.44	1.14	6.94	0.71	6.94	0.44
	1992	16.12	1.14	15.81	0.97	25.06	1.25	25.11	1.01	5.88	0.52	6.31	0.63
	1993	8.45	0.70	10.00	0.97	21.15	0.97	23.69	1.31	4.82	0.49	6.11	0.65
Bark insects[B]	1986	1.21	0.21	1.78	0.28	1.30	0.22	1.94	0.28	1.58	0.30	2.69	0.43
	1987	0.48	0.12	1.14	0.24	1.94	0.30	3.14	0.44	3.21	0.54	4.08	0.55
	1988	1.45	0.20	2.14	0.42	1.36	0.26	3.22	0.40	2.64	0.41	3.53	0.52
	1989	0.88	0.20	1.61	0.25	1.61	0.24	2.25	0.29	3.88	0.74	3.42	0.46
	1990	1.42	0.28	2.03	0.28	1.85	0.30	1.81	0.25	1.36	0.22	2.03	0.29
	1991	0.67	0.14	1.78	0.33	1.33	0.28	2.03	0.33	3.76	0.57	3.25	0.39
	1992	1.76	0.29	2.00	0.28	2.91	0.39	3.17	0.48	3.21	0.50	3.36	0.43
	1993	1.52	0.30	1.92	0.29	2.03	0.35	2.39	0.33	2.36	0.32	2.72	0.32

Table 3 (continued)

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Guild	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mixed coniferous[S] and deciduous	1986	2.91	0.41	4.81	0.59	4.79	0.37	4.89	0.54	1.09	0.27	1.42	0.27
	1987	1.52	0.25	3.22	0.58	4.85	0.43	5.86	0.56	1.45	0.28	1.42	0.27
	1988	2.27	0.32	2.69	0.45	4.09	0.41	4.92	0.44	1.52	0.28	1.89	0.38
	1989	1.82	0.30	1.42	0.27	4.91	0.57	6.03	0.53	2.64	0.39	2.81	0.32
	1990	2.58	0.45	3.19	0.46	4.55	0.46	5.11	0.48	1.39	0.22	1.50	0.25
	1991	1.18	0.20	3.17	0.56	4.94	0.42	5.17	0.55	1.48	0.29	2.03	0.27
	1992	3.27	0.43	3.36	0.40	5.45	0.56	6.69	0.59	1.39	0.25	1.39	0.26
	1993	2.27	0.36	2.83	0.44	4.79	0.33	5.64	0.63	0.70	0.18	0.86	0.17
Permanent res.[B]	1986	3.00	0.48	3.39	0.43	3.82	0.52	4.25	0.62	5.15	0.70	8.92	1.11
	1987	1.94	0.32	2.86	0.49	5.03	0.61	7.28	0.81	9.67	0.94	10.36	0.83
	1988	4.48	0.51	5.28	0.49	3.58	0.51	5.69	0.75	7.97	1.46	8.19	0.99
	1989	3.85	0.45	3.61	0.48	3.85	0.51	4.69	0.47	11.24	1.74	8.64	1.07
	1990	3.06	0.39	4.19	0.54	4.97	0.71	3.86	0.48	5.42	0.57	7.00	0.69
	1991	2.91	0.45	2.61	0.31	3.79	0.58	4.92	0.54	10.36	1.15	8.64	0.80
	1992	3.58	0.47	3.69	0.40	7.39	1.09	6.25	0.77	7.39	0.68	7.69	0.66
	1993	4.76	0.53	4.86	0.42	5.09	0.68	5.31	0.53	6.42	0.75	7.28	0.63

Table 3 (continued)

Guild	Year	Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Short-distance migrants[F]	1986	9.39	0.83	11.33	1.11	11.97	1.20	11.75	1.40	6.58	0.88	7.42	1.00
	1987	10.33	1.16	11.25	1.19	14.09	1.78	13.28	1.32	10.61	1.57	6.83	0.89
	1988	11.73	1.20	13.22	1.07	11.36	1.08	10.67	0.91	6.36	0.82	6.69	0.94
	1989	9.94	1.29	11.03	1.02	11.24	1.22	11.14	1.23	9.15	1.49	6.11	0.85
	1990	8.45	1.04	8.64	0.84	9.30	0.98	8.97	1.00	3.58	0.58	4.67	0.70
	1991	7.36	0.95	9.22	0.89	9.64	0.90	10.72	1.08	4.55	0.66	5.61	0.57
	1992	8.45	1.10	8.19	0.86	9.82	0.94	10.14	0.89	4.73	0.79	3.94	0.60
	1993	10.03	1.23	10.03	0.87	9.33	1.13	11.69	1.09	3.21	0.57	3.36	0.41
Long-distance migrants[S]	1986	10.48	0.88	15.44	0.87	23.03	1.18	25.19	1.19	2.76	0.59	4.97	1.11
	1987	6.33	0.74	7.03	0.75	24.09	1.47	23.61	1.26	3.30	0.52	3.58	0.69
	1988	2.70	0.44	4.14	0.51	19.76	1.17	20.42	1.24	2.36	0.34	4.39	0.60
	1989	0.03	0.03	0.22	0.07	19.55	1.28	21.89	1.18	4.70	0.79	4.72	0.59
	1990	8.15	1.08	7.44	0.64	17.73	1.46	19.83	1.21	3.33	0.44	4.81	0.54
	1991	4.06	0.86	7.75	1.54	19.15	1.02	21.97	1.34	3.82	0.55	4.06	0.36
	1992	13.27	1.45	14.08	1.40	22.61	1.27	25.33	1.26	2.85	0.42	3.28	0.48
	1993	3.55	0.59	4.47	0.91	18.82	0.98	20.44	1.24	1.76	0.30	2.67	0.37

Table 3 (continued)

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Guild	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Ground nest[F]	1986	10.82	1.05	12.39	0.86	17.36	1.22	14.47	1.08	3.24	0.56	4.33	0.87
	1987	9.06	1.07	7.33	0.62	18.27	1.20	14.67	0.95	4.70	0.86	2.47	0.46
	1988	5.76	0.75	6.81	0.71	14.79	1.04	13.53	0.98	3.52	0.49	3.42	0.43
	1989	3.64	0.65	2.83	0.38	16.21	1.23	15.11	0.92	6.21	1.21	3.44	0.42
	1990	8.82	1.30	7.14	0.72	13.30	1.12	11.61	0.84	2.06	0.30	2.83	0.39
	1991	5.58	0.86	6.22	0.79	13.97	1.17	13.31	0.83	3.21	0.46	3.39	0.40
	1992	11.18	1.16	10.28	0.81	15.09	0.90	15.00	0.84	2.27	0.38	2.03	0.36
	1993	6.67	0.88	6.11	0.63	14.97	1.04	13.03	0.76	1.06	0.22	1.33	0.21
Cavity nest[B]	1986	2.48	0.32	3.53	0.60	4.36	0.51	5.03	0.59	5.03	0.72	8.42	1.12
	1987	1.88	0.29	3.81	0.59	4.45	0.53	8.47	0.91	7.82	0.89	10.03	1.01
	1988	4.73	0.41	6.64	0.73	3.70	0.56	6.31	0.70	6.24	0.66	8.47	0.99
	1989	3.94	0.56	5.61	0.50	3.12	0.36	5.39	0.43	8.85	1.17	8.22	1.07
	1990	2.91	0.38	4.50	0.45	4.18	0.66	4.28	0.46	4.09	0.51	5.97	0.58
	1991	2.94	0.39	4.19	0.57	3.67	0.56	5.25	0.51	7.73	0.91	7.61	0.66
	1992	3.24	0.43	4.58	0.49	6.36	0.69	7.33	0.87	6.88	0.67	7.97	0.68
	1993	4.64	0.49	5.31	0.51	4.52	0.62	5.75	0.58	6.33	0.70	7.39	0.67

One of 18 tests among habitat guilds indicated that changes in abundance over time in treatment and reference areas differed (Table 3; Figure 17, p 31). For this guild group, numbers of birds that prefer mixed forests showed a significant interaction ($P < 0.01$) during spring migration. Overall, numbers have declined in both treatment and reference areas from 1986 to 1993 but the magnitude of declines have been higher in reference than treatment areas (Table 3). A significant contrast was detected between the low and transitional exposure periods.

Three of nine tests of migration guild parameters (three types X three seasons) indicated a significant interaction ($P < 0.05$) in the repeated measure ANOVA (Table 3). No consistent patterns emerged for any migration group across seasons. For example, changes in numbers of long-distant migrants over years was not the same ($P < 0.01$) on reference and treatment transects during spring migration (Figure 17). Significant interactions ($P < 0.04$) were found for permanent resident species during the breeding season (Figure 19). During fall migration, a significant interaction was found for number of short-distant migrants ($P < 0.04$) (Figure 18). Significant contrasts were detected for short-distance migrants between the low and high exposure years and between the transitional and high exposure periods.

A small percentage of significant tests among nesting guilds was found (2 of 18) (Table 3). Number of birds that nest in cavities were consistently higher in reference than treatment areas over all years (Figure 19). However, numbers in treatment areas fluctuated more over years than numbers in reference areas, especially from 1990 to 1991 (Table 3). Overall numbers, however, have increased from 1986 to 1993 in both reference and treatment areas during the breeding season. Number of ground nesting birds observed during fall migration have declined in both reference and treatment areas over time, but numbers on treatment transects have fluctuated more widely during this time period than numbers counted in reference areas (Table 3). A significant contrast was detected for ground nesting birds between the transitional and high exposure years (Figure 18).

Individual species. Three of 38 species (8%) tested in the spring migration season indicated a significant interaction in abundance over years ($P < 0.05$) between reference and treatment study areas (Table 4, p 18). Patterns of species abundance over years in treatment and reference areas for these three species showed two different patterns. For one species, the Black-and-white Warbler abundance in treatment and reference areas have varied similarly over time (Figure 8, p 23). Abundance patterns for two species, the Rose-breasted Grosbeak (Figure 9, p 23) and Song Sparrow (Figure 10, p 24) varied considerably but not consistently in treatment and reference areas over years (Table 4). For these species, however,the number observed has declined more in reference than in treatment areas from pre to post-impact years. Two significant contrasts were observed for the Black-and-white Warbler, one between the low and transitional impact periods, and the other between the transitional and high impact years. The Rose-breasted Grosbeak indicated a significant difference in change in abundance between treatment and reference from the low to transitional years.

Table 4. Mean number (per 500 m transect) and standard error of species that showed a significant interaction in abundance over years (repeated measures ANOVA) between treatment and reference. Superscript letter indicates season where significant difference was found (S=spring migration, B=breeding, F=fall migration).

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Parameter	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Great Crested Flycatcher[B]	1986	0.09	0.05	0.17	0.07	0.39	0.11	0.72	0.13	0.06	0.04	0.08	0.05
	1987	0.00	0.00	0.06	0.04	0.39	0.13	0.92	0.17	0.06	0.06	0.08	0.05
	1988	0.03	0.03	0.19	0.08	0.33	0.09	0.56	0.15	0.03	0.03	0.06	0.04
	1989	0.00	0.00	0.06	0.04	0.12	0.06	0.78	0.14	0.03	0.03	0.06	0.06
	1990	0.09	0.05	0.19	0.07	0.12	0.07	0.53	0.14	0.00	0.00	0.03	0.03
	1991	0.03	0.03	0.11	0.05	0.39	0.14	0.39	0.11	0.03	0.03	0.19	0.07
	1992	0.06	0.04	0.25	0.10	0.18	0.07	0.64	0.16	0.03	0.03	0.14	0.07
	1993	0.03	0.03	0.06	0.04	0.30	0.10	0.36	0.10	0.00	0.00	0.14	0.06
American Woodcock[F]	1986	0.06	0.04	0.00	0.00	0.06	0.04	0.17	0.09	0.12	0.07	0.00	0.00
	1987	0.00	0.00	0.03	0.03	0.12	0.09	0.28	0.14	0.18	0.08	0.08	0.05
	1988	0.00	0.00	0.00	0.00	0.12	0.06	0.11	0.05	0.36	0.16	0.03	0.03
	1989	0.03	0.03	0.03	0.03	0.15	0.09	0.08	0.06	0.21	0.08	0.14	0.07
	1990	0.12	0.07	0.03	0.03	0.09	0.07	0.00	0.00	0.06	0.04	0.08	0.05
	1991	0.03	0.03	0.00	0.00	0.06	0.04	0.17	0.08	0.03	0.03	0.08	0.05
	1992	0.00	0.00	0.08	0.06	0.03	0.03	0.06	0.04	0.06	0.04	0.03	0.03
	1993	0.06	0.04	0.00	0.00	0.12	0.09	0.03	0.03	0.03	0.03	0.11	0.05

Table 4 (continued)

		Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
Parameter	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Red-breasted Nuthatch[B]	1986	0.27	0.11	0.17	0.07	0.27	0.13	0.25	0.08	0.70	0.18	0.69	0.15
	1987	0.21	0.09	0.31	0.12	0.36	0.10	0.67	0.13	1.58	0.35	2.08	0.30
	1988	0.82	0.17	0.78	0.20	0.52	0.15	0.94	0.18	1.06	0.26	1.61	0.25
	1989	0.21	0.07	0.25	0.10	0.45	0.12	0.83	0.15	2.88	0.61	1.97	0.31
	1990	0.48	0.15	0.69	0.20	0.67	0.18	0.31	0.12	0.45	0.13	0.78	0.19
	1991	0.09	0.07	0.14	0.07	0.30	0.14	0.39	0.13	2.12	0.46	1.39	0.23
	1992	0.67	0.18	0.67	0.13	1.42	0.35	0.94	0.21	1.73	0.31	1.53	0.31
	1993	0.73	0.20	0.78	0.17	0.61	0.16	0.67	0.14	0.58	0.12	0.56	0.14
Golden-crowned Kinglet[F]	1986	1.06	0.37	0.42	0.18	1.15	0.34	0.94	0.27	1.97	0.48	1.78	0.38
	1987	1.45	0.37	1.17	0.26	2.30	0.71	1.03	0.25	3.88	0.87	1.67	0.57
	1988	1.48	0.34	1.78	0.48	1.48	0.37	1.22	0.40	2.15	0.55	1.67	0.43
	1989	1.58	0.41	0.86	0.26	1.36	0.32	0.94	0.31	2.21	0.52	1.44	0.53
	1990	1.06	0.29	1.00	0.31	1.24	0.32	0.83	0.33	0.94	0.27	1.14	0.42
	1991	1.06	0.29	0.83	0.22	1.70	0.37	1.56	0.36	0.61	0.16	0.47	0.16
	1992	1.12	0.45	0.36	0.14	1.73	0.37	0.64	0.21	0.67	0.19	0.31	0.13
	1993	0.30	0.13	0.33	0.11	1.61	0.39	1.50	0.50	0.12	0.07	0.33	0.14

Table 4 (continued)

Parameter	Year	Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Black-and-white Warbler[s]	1986	0.52	0.17	0.92	0.21	0.45	0.14	0.69	0.17	0.12	0.08	0.08	0.05
	1987	0.06	0.04	0.33	0.09	0.67	0.18	0.97	0.26	0.15	0.08	0.08	0.08
	1988	0.09	0.05	0.36	0.11	0.42	0.13	0.97	0.16	0.06	0.04	0.33	0.14
	1989	0.00	0.00	0.00	0.00	0.48	0.13	0.75	0.15	0.15	0.08	0.14	0.06
	1990	0.55	0.21	0.67	0.14	0.61	0.16	0.72	0.16	0.21	0.08	0.14	0.06
	1991	0.18	0.09	0.44	0.12	0.39	0.15	0.64	0.15	0.15	0.11	0.11	0.05
	1992	0.42	0.12	0.64	0.14	0.45	0.13	0.97	0.18	0.21	0.09	0.11	0.07
	1993	0.03	0.03	0.22	0.08	0.42	0.14	0.47	0.14	0.12	0.07	0.17	0.06
Rose-breasted Grosbeak[s]	1986	0.06	0.04	0.94	0.23	0.94	0.23	1.47	0.27	0.00	0.00	0.11	0.09
	1987	0.12	0.07	0.22	0.08	0.82	0.19	0.67	0.12	0.24	0.10	0.08	0.06
	1988	0.03	0.03	0.03	0.03	1.03	0.18	1.19	0.19	0.03	0.03	0.11	0.07
	1989	0.00	0.00	0.00	0.00	0.67	0.18	1.11	0.22	0.12	0.07	0.08	0.06
	1990	0.39	0.15	0.39	0.11	0.79	0.24	1.00	0.19	0.15	0.09	0.11	0.07
	1991	0.30	0.17	0.47	0.14	0.42	0.12	1.11	0.18	0.12	0.06	0.03	0.03
	1992	1.06	0.30	0.69	0.13	0.97	0.19	1.03	0.18	0.12	0.09	0.00	0.00
	1993	0.06	0.04	0.19	0.10	0.18	0.08	0.42	0.11	0.00	0.00	0.03	0.03

Table 4 (continued)

Parameter	Year	Spring Migration				Breeding				Fall Migration			
		Treatment		Reference		Treatment		Reference		Treatment		Reference	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Chipping Sparrow[B]	1986	0.24	0.10	0.81	0.20	0.58	0.18	0.58	0.18	0.12	0.09	0.00	0.00
	1987	0.67	0.25	0.56	0.23	0.39	0.17	0.44	0.19	0.15	0.11	0.03	0.03
	1988	0.52	0.19	0.42	0.17	0.64	0.17	0.33	0.13	0.06	0.06	0.03	0.03
	1989	0.21	0.09	0.25	0.13	0.70	0.20	0.28	0.12	0.36	0.18	0.08	0.08
	1990	0.12	0.07	0.11	0.09	0.48	0.19	0.28	0.13	0.00	0.00	0.06	0.06
	1991	0.12	0.06	0.50	0.27	0.21	0.07	0.36	0.14	0.00	0.00	0.36	0.21
	1992	0.33	0.13	0.50	0.25	0.33	0.12	0.50	0.26	0.06	0.04	0.08	0.06
	1993	0.15	0.08	0.17	0.09	0.64	0.23	0.50	0.19	0.12	0.12	0.08	0.06
Song Sparrow[S]	1986	0.09	0.05	0.19	0.10	0.39	0.13	0.72	0.19	0.09	0.07	0.19	0.10
	1987	0.36	0.15	0.31	0.10	0.39	0.16	0.75	0.22	0.27	0.15	0.11	0.05
	1988	0.52	0.17	0.17	0.09	0.36	0.11	0.28	0.09	0.09	0.05	0.11	0.09
	1989	0.24	0.09	0.42	0.16	0.24	0.10	0.47	0.15	0.39	0.22	0.17	0.07
	1990	0.36	0.10	0.06	0.04	0.15	0.06	0.19	0.07	0.03	0.03	0.00	0.00
	1991	0.00	0.00	0.19	0.08	0.21	0.10	0.39	0.13	0.03	0.03	0.03	0.03
	1992	0.24	0.10	0.22	0.10	0.18	0.09	0.61	0.16	0.03	0.03	0.06	0.04
	1993	0.12	0.06	0.17	0.09	0.12	0.06	0.56	0.18	0.12	0.07	0.06	0.04

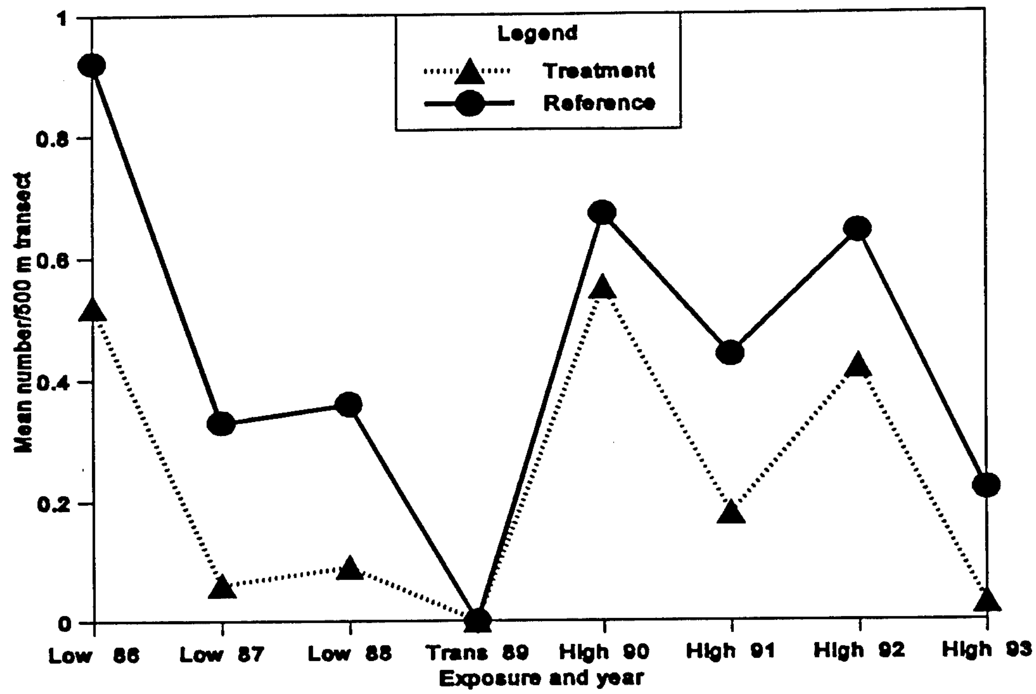

Figure 8. Mean number of Black-and-white Warblers observed/500 m transect in reference and treatment study areas during spring migration from 1986 to 1993.

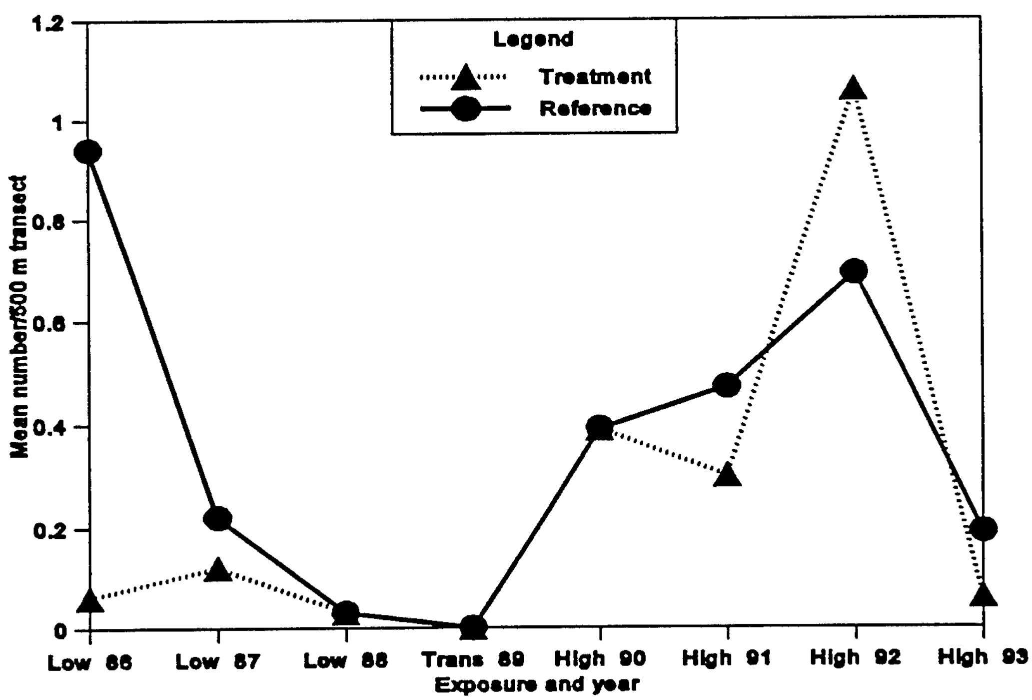

Figure 9. Mean number of Rose-breasted Grosbeaks observed/500 m transect in reference and treatment study areas during spring migration 1986 to 1993.

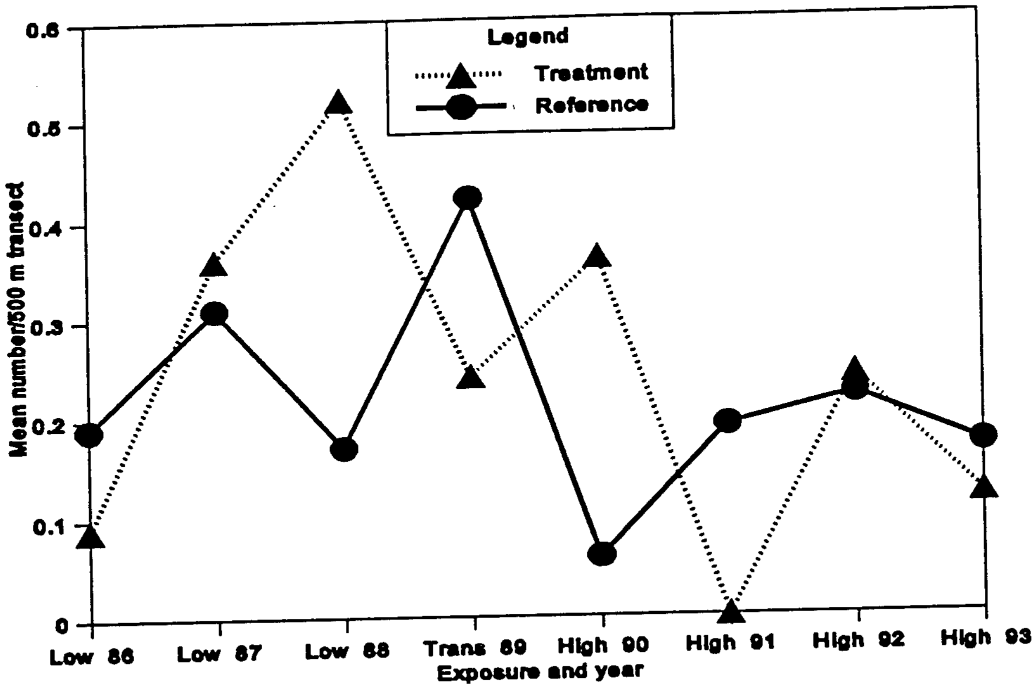

Figure 10. Mean number of Song Sparrows observed/500 m transect in reference and treatment study areas during spring migration 1986 to 1993.

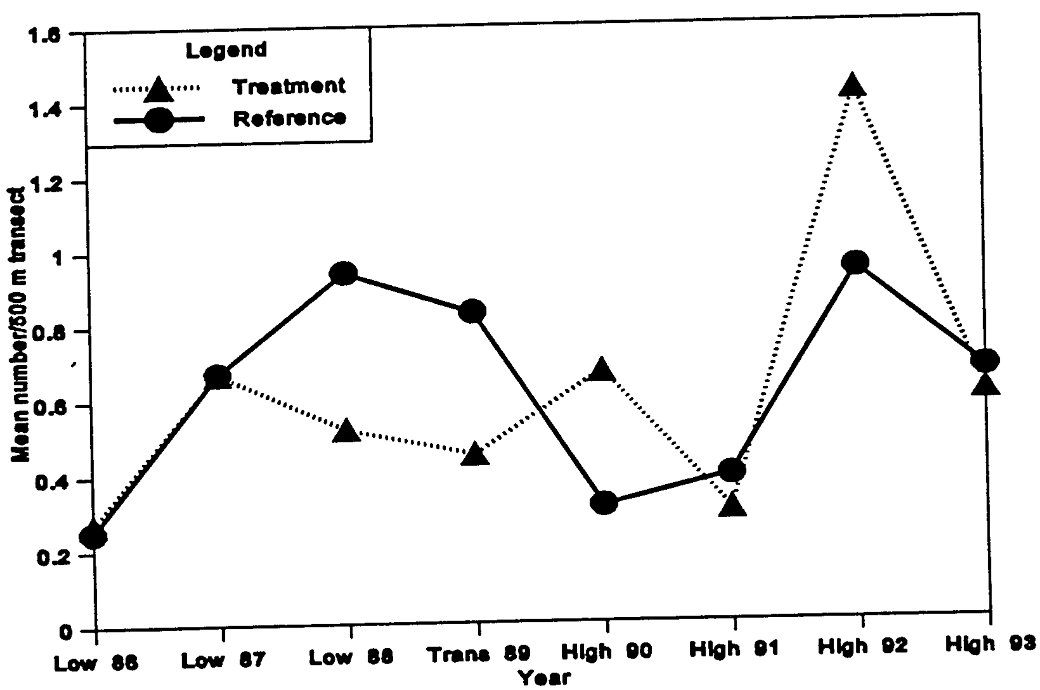

Figure 11. Mean number of Red-breasted Nuthatches observed/500 m transect in reference and treatment study areas during the breeding season 1986 to 1993.

Three of 54 (5%) species tested indicated that changes in abundance over years were significantly ($P < 0.05$) different between reference and treatment study areas in the breeding season (Table 4). Patterns of changes in abundance for all three species; Red-breasted Nuthatch (Figure 11, p 24), Great Crested Flycatcher (Figure 12), and Chipping Sparrow (Figure 13, p 26) have been highly variable in both treatment and reference areas over years. However, relative abundance patterns in pre-treatment and in post-treatment years on treatment and reference transects have been similar (Table 4). All three species showed a significant contrast between the transitional to high exposure periods. In addition, change in abundance for the Great Crested Flycatcher was different between reference and treatment areas from the low to transitional periods and for the Red-breasted Nuthatch, from the low to high exposure years.

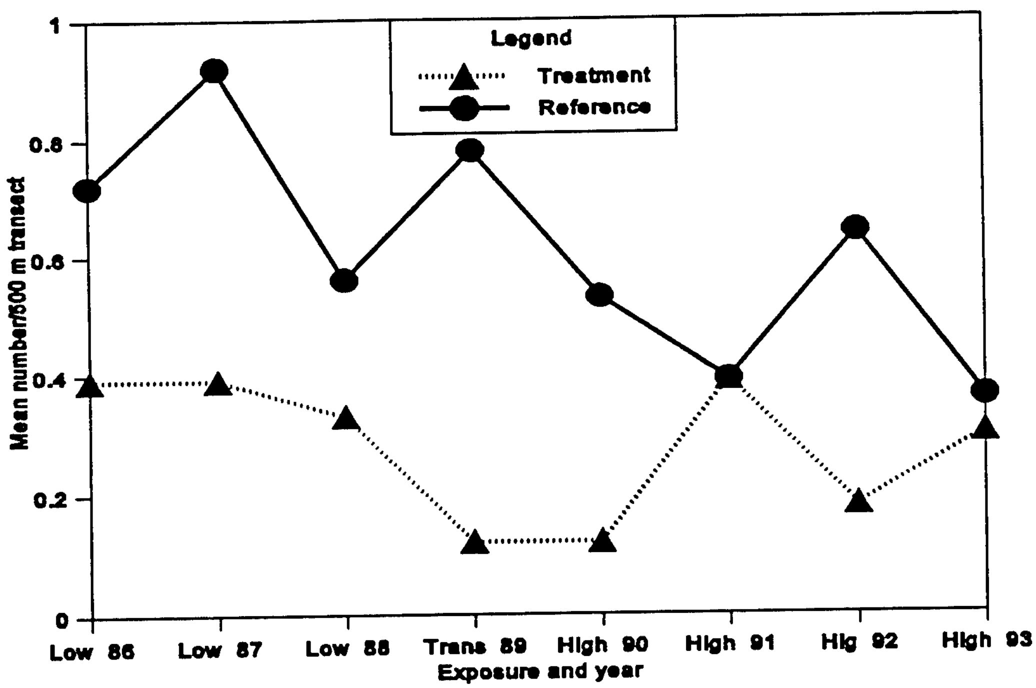

Figure 12. Mean number of Great Crested Flycatchers observed/500 m transect in reference and treatment study areas during the breeding season 1986 to 1993.

Six percent (2 of 33) of the species tested in the fall migration period indicated a significant difference ($P < 0.05$) in abundance over years in treatment and reference study areas (Table 4). Abundance patterns for two species, Golden-crowned Kinglet (Figure 14, p 26) and American Woodcock (Figure 15, p 27), have declined more overall in treatment than reference study areas over years (Table 4). Significant contrasts for the Woodcock were detected between the low and high and between the transitional to high exposure periods.

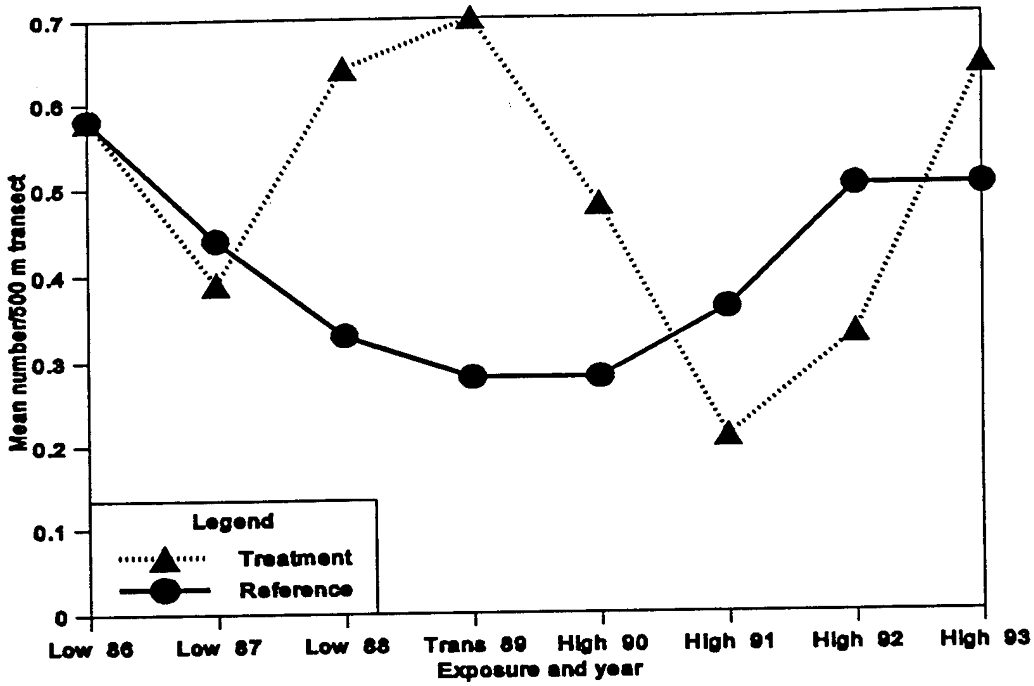

Figure 13. Mean number of Chipping Sparrows observed/500 m transect in reference and treatment study areas during the breeding season 1986 to 1993.

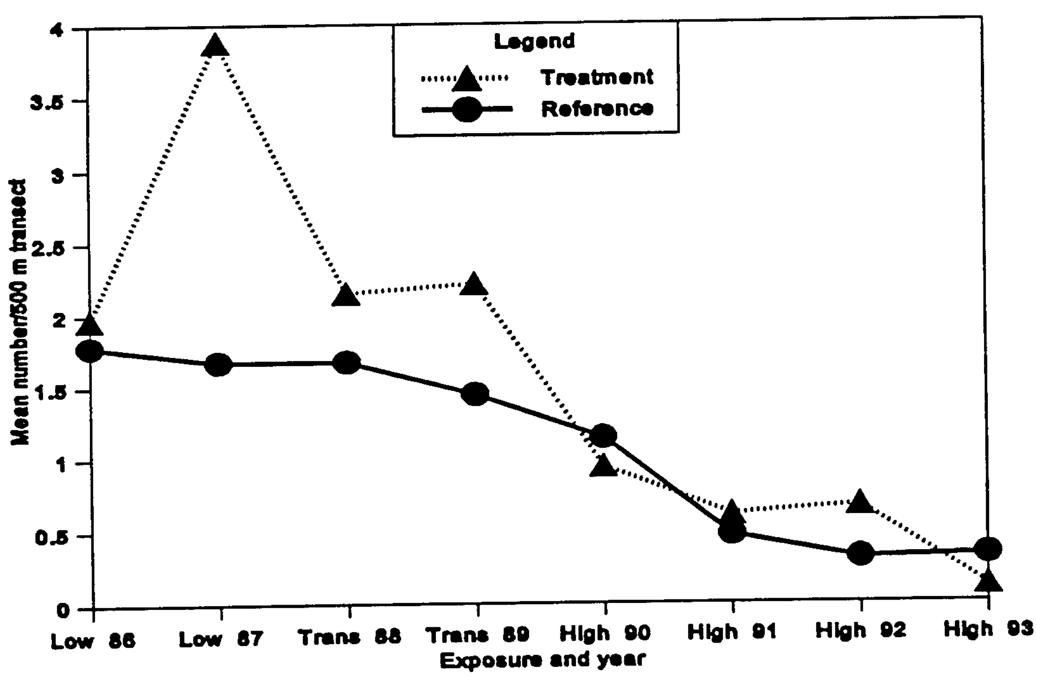

Figure 14. Mean number of Golden-crowned Kinglets observed/500 m transect in reference and treatment study areas during fall migration 1986 to 1993.

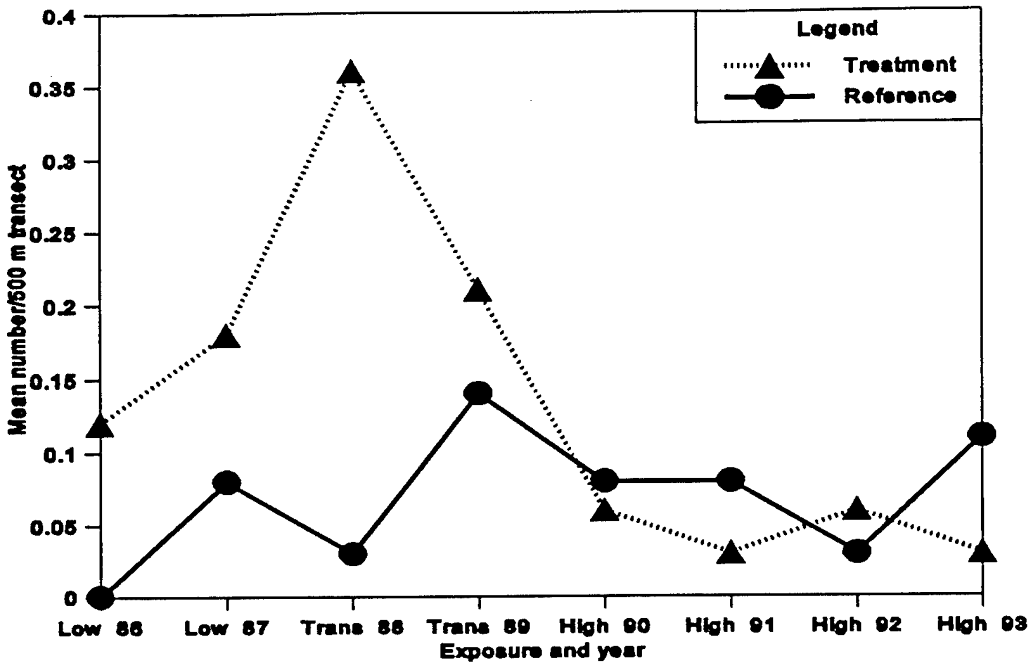

Figure 15. Mean number of American Woodcocks observed/500 m transect in reference and treatment study areas during fall migration 1986 to 1993.

Power analysis. Results of the power analysis indicated that the repeated measures univariate test is a powerful test for detecting differences in abundance patterns between treatment and reference study areas. The calculated power for detecting a 10% change was 1.00 for any parameter that had a CV < 0.90 (Figure 16, p 28). This group included 6 species and 18 guild and community parameters during spring migration, 12 species and 19 guild and community parameters during the breeding season, and 3 species and 15 guild and community parameters for the fall migration period. Power for a 25% change was 1.00 for parameters that had a CV < 2.5. This group included 20 species and 2 guild parameters during spring migration, 29 species during the breeding season, and 16 species and 4 guild parameters during the fall migration period. Power for tests to detect a 50% change included all species and guild parameters in all seasons (any CV value). See Appendix 6 for grand mean and CV values that were used in the power calculation.

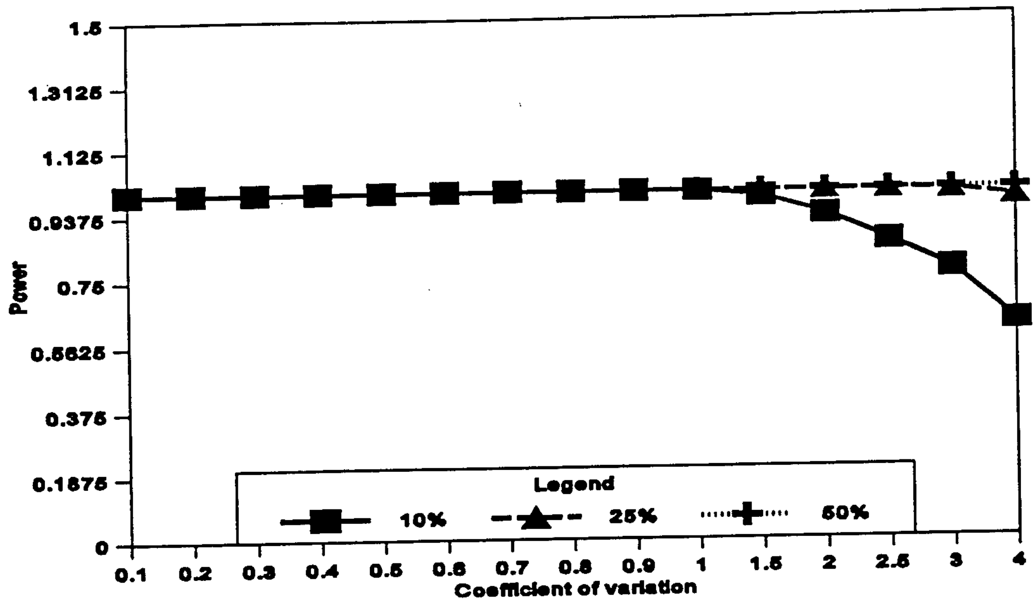

Figure 16. Power of univariate repeated measures analysis of variance for a 10%, 25%, and 50% difference between means (treatment-by-year interaction) for different coefficients of variation (see Appendix 6).

DISCUSSION

Bird community abundance patterns. We found no convincing evidence that overall breeding bird distribution or abundance was affected by EM fields produced by the ELF antenna. Breeding bird communities (number of species, number of individuals) varied substantially over the eight years of this study; a similar pattern in variation was found in northern Wisconsin (Hanowski et al. 1993; Blake et al. 1994). Although numbers varied annually, consistent patterns for numbers of individuals and species on treatment and reference study areas were evident; reference areas had more species and individuals than treatment study areas in all years. Patterns in abundance for birds in the period when they are most stationary, and therefore receive the most exposure to EM fields, were the same before and after the antenna was operated.

Annual variation in abundance was greatest during both migration periods, the time when birds are moving through the study areas. Number of individuals and species observed during spring migration reflected patterns found during the breeding season; numbers were consistently higher in reference than in treatment study areas in all years. Although a significant interaction in number of species observed in the spring migration was found between reference and treatment study areas, the trend has been for numbers observed to converge over time (see Figure 5, p.8). Thus, this difference is not likely due to repulsion of birds due to EM fields during spring migration.

Abundance patterns for individuals and species was most variable from year to year during the fall migration period, especially for number of individuals. Although numbers observed in reference areas have been fairly consistent over time, numbers observed on treatment transects have varied considerably, being higher than reference areas in three years, lower in three years, and equal to references in one year (Figure 7, p 12). However, because this alternating pattern in abundance has occurred both before and after the antenna was fully operated, it is unlikely due to EM fields related to the operation of the antenna.

Variation from year to year in bird abundance may reflect timing of sampling in relation to migration phenology. Weather during migration may profoundly influence abundance of birds in a particular area (Richardson, 1978). Thus, differences in weather from one year to the next may produce apparent (as well as real) differences in bird abundance. If arrival of most migrants was later in one year than in another, we might record substantial variation in abundance between years (particularly in September). We attempted to minimize this by sampling at approximately the same period (calendar date) each year. In addition, we sampled two times during the breeding and fall migration seasons and used the maximum number of individuals observed in our analyses. This method should partially control for annual phenological differences in bird detection. Patterns of annual variation, however, were similar in treatment and reference areas during breeding and spring migration. This indicates that birds likely responded to environmental conditions and not to EM fields produced by the antenna (see Rogers, 1981). Reasons for the increasing and decreasing pattern observed for number of individuals on treatment areas during the fall migration period are unclear. It is possible that ELF EM fields contributed to this pattern, but the biological significance is unclear.

The Michigan facility was operated well below full strength in 1986, 1987 and half of 1988 (15 amperes, 8 hr/day, weekdays, starting 1 June 1987 through 2 July 1988) and at 75 amperes (8 hr/day, weekdays) for the remainder of 1988. It was operated at 150 amperes for 16-24 hr/day during most of the 1989 sampling period and during all of 1990, 1991, 1992, and 1993. There has been, however, little noticeable change in bird populations on treatment segments relative to those on reference segments. Further, major declines occurred before the antenna began operation in 1988. No consistent patterns are yet evident to indicate that changes in abundance on treatment segments have been more pronounced than on reference segments since the antenna became fully operational. That is, after the antenna became fully operational in 1989, patterns in abundance on treatment and reference segments have not been significantly altered.

Results from the Wisconsin study also indicated that there was little consistency among years or seasons in species richness or number of individuals (Hanowski et al. 1993). If the ELF transmitter strongly influenced bird distribution patterns, one might expect that changes in relative abundance of birds on treatment and reference segments would be somewhat consistent (within each group) from one year to the next, particularly during the breeding season, and from one season to the next. There was, however, little or no evidence for such a pattern. In Wisconsin, species and individuals were more abundant on treatment segments in 1985 and individuals were more

abundant on treatment segments in 1986, but no other significant difference at the community level were noted. In fact, throughout 1986-1989, species richness and abundance of individuals were remarkably similar on treatment and reference segments in Wisconsin (Hanowski et al. 1991).

Guild distribution patterns. Overall patterns in bird communities may mask differences that are present at the species or guild levels. Species that belong to the same "guild" share some biological characteristics. Thus, if the ELF antenna system influenced the distribution patterns of birds, we might expect members of a particular guild to be influenced in a similar fashion.

Relatively few differences in abundance of birds in different guilds were noted between treatment and reference segments in Michigan. We attributed many differences that we detected in our studies in Wisconsin to differences in amounts and types of habitats present in treatment and reference study areas. Because we had no before-treatment data, we could not determine whether differences in bird abundance were due to habitat or to EM fields. In this study, we have data before the antenna became fully operational and,therefore, we can rule out that differences between reference and treatment transects were due to habitat. This assumption appears to be valid for the Michigan study based on results of the guild analyses for habitat. In this analyses, only one of eighteen tests indicated a significant interaction, only slightly more than would be expected by chance. This result indicates that any successional changes in habitats that have occurred in Michigan over the past eight years have been parallel in treatment and reference areas and that birds have responded similarly to these changes in both areas.

Individual guild parameters that have shown significant interactions in abundance between treatment and reference study areas in the breeding season from three groups (nesting, migration, and foraging) are related. Similarity in results is likely due to the influence of the same species that are included within the different groups. For example, number of cavity nesters, permanent residents, and bark foragers all showed significant interactions in abundance between reference and treatment study areas and also very similar abundance patterns (Figure 19, p 34). Most permanent residents (e.g., woodpeckers) nest in cavities and feed on bark insects. Abundance patterns for these groups indicate that all were more abundant in reference than in treatment areas, except in 1990 when slightly more permanent residents and bark insect foragers were observed in treatment areas (Figure 19). Because permanent residents are present in the areas year around, we might expect that they would receive the largest amount of exposure to EM fields. Patterns of changes in abundance over time in treatment and reference areas, however, do not reflect a pattern that would be expected if birds were negatively responding to EM fields.

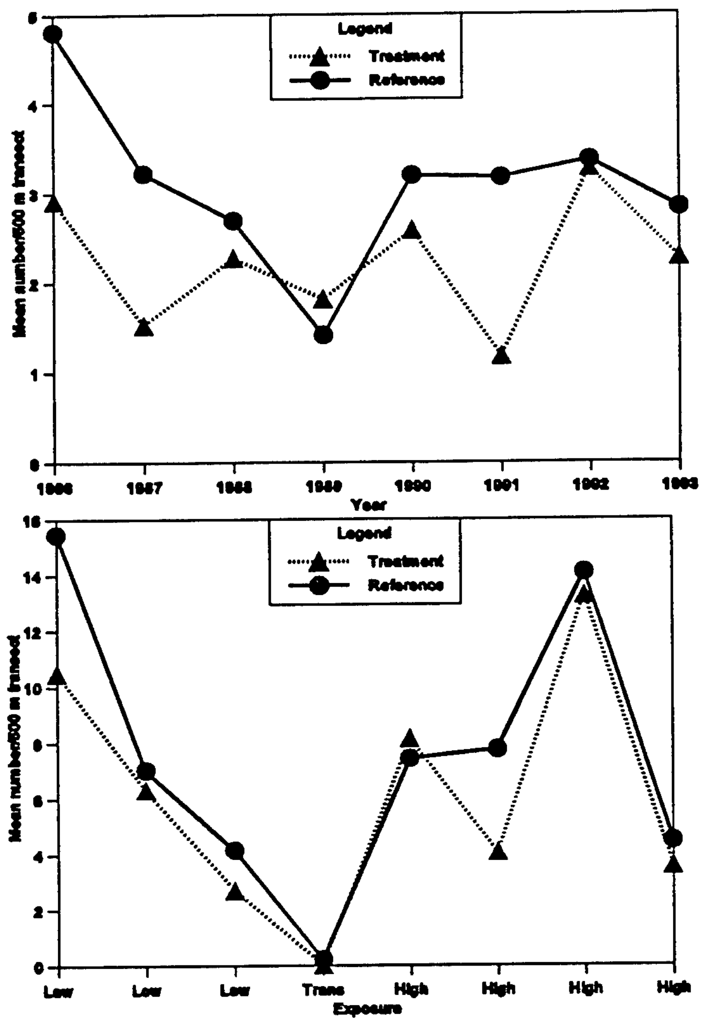

Figure 17. Mean number/500 m transect of mixed coniferous and deciduous forest birds (top) and long-distance migrants observed on reference and treatment study areas in spring migration 1986 to 1993.

Patterns among guild groups that showed a significant interaction for the fall migration season were similar to those found in the breeding season. The number of short-distance migrants, ground nesters, and foliage gleaners showed significant interaction among years between reference and treatment areas during this time period (Figure 18, p 33). Abundance patterns for these groups are similar because many short-distance migrants are ground nesters and feed on foliage insects and we would expect similar patterns in abundance. Number of individuals within these groups have shown a fairly steady decline in both treatment and reference areas over the years, with treatment areas showing more variation from year to year, especially before 1990. This pattern of change is not likely due to negative effects of EM fields, primarily because in years where the magnitude of fluctuation in treatments was greatest, numbers exceeded the reference areas, whereas in most other years, numbers in reference areas were higher than in treatment areas (Figure 18, p 33).

INDIVIDUAL SPECIES

EM exposure differences that exist between treatment and reference segments may not influence all bird species in the same manner. If some species are more abundant in reference areas (possible negative response) and others on treatment segments (possible positive response), then such differences might cancel each other, producing nonsignificant results at the community level. If differences between treatment and reference segments (related to EM fields) is a primary factor influencing distribution patterns of individual species, then we might expect those species to show similar patterns among years and seasons.

There have, however, been no cases where differences in abundance of a species between treatment and reference segments have remained consistently significant among seasons in Michigan. In addition, numbers of significant differences (8 of 25 or 6%) detected were not much greater than what would be expected by chance alone. If the antenna operation adversely affected bird species, we might have expected numbers on treatment segments to decline after operation began. No such patterns were evident over the eight years of sampling in any of the three seasons.

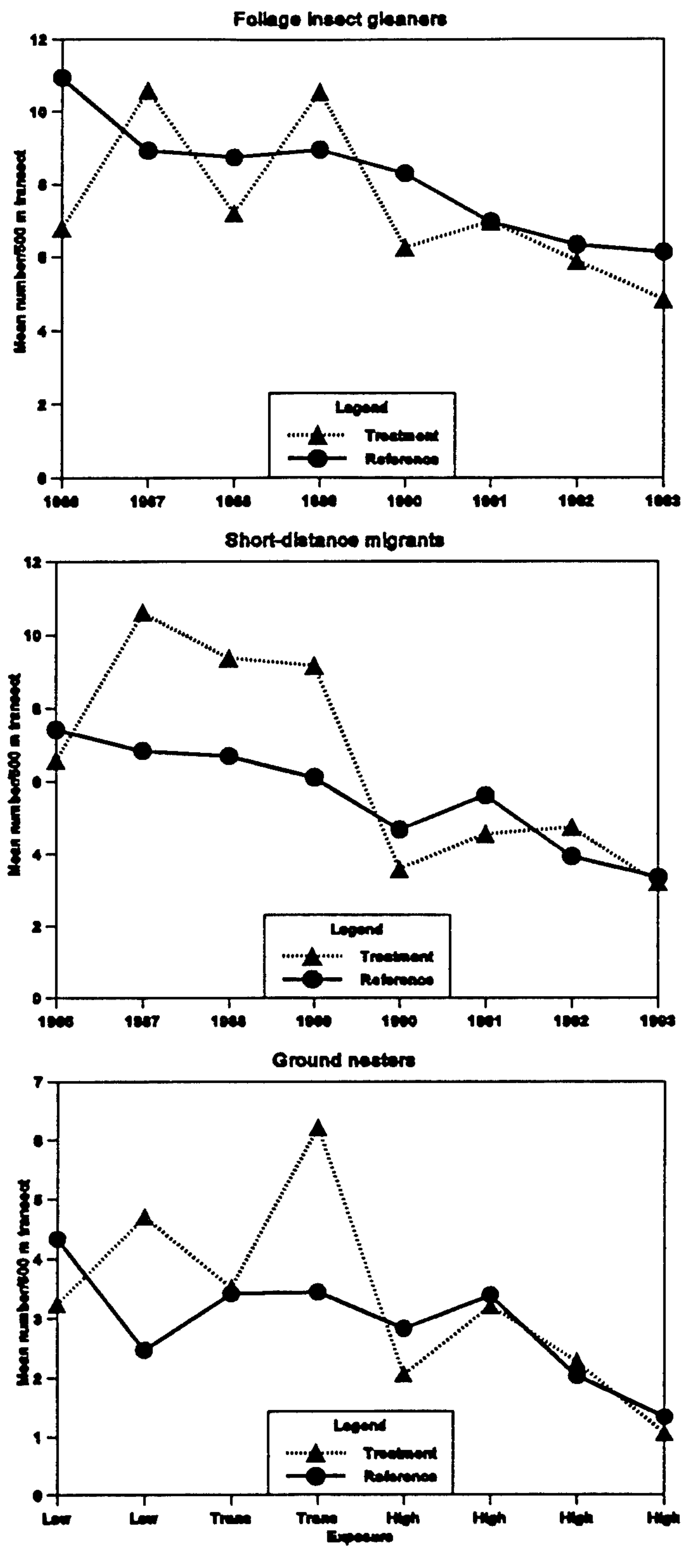

Figure 18. Mean number/500 m transect of foliage gleaners, short-distance migrants, and ground nesters during the fall migration season on reference and treatment study areas from 1986 to 1993.

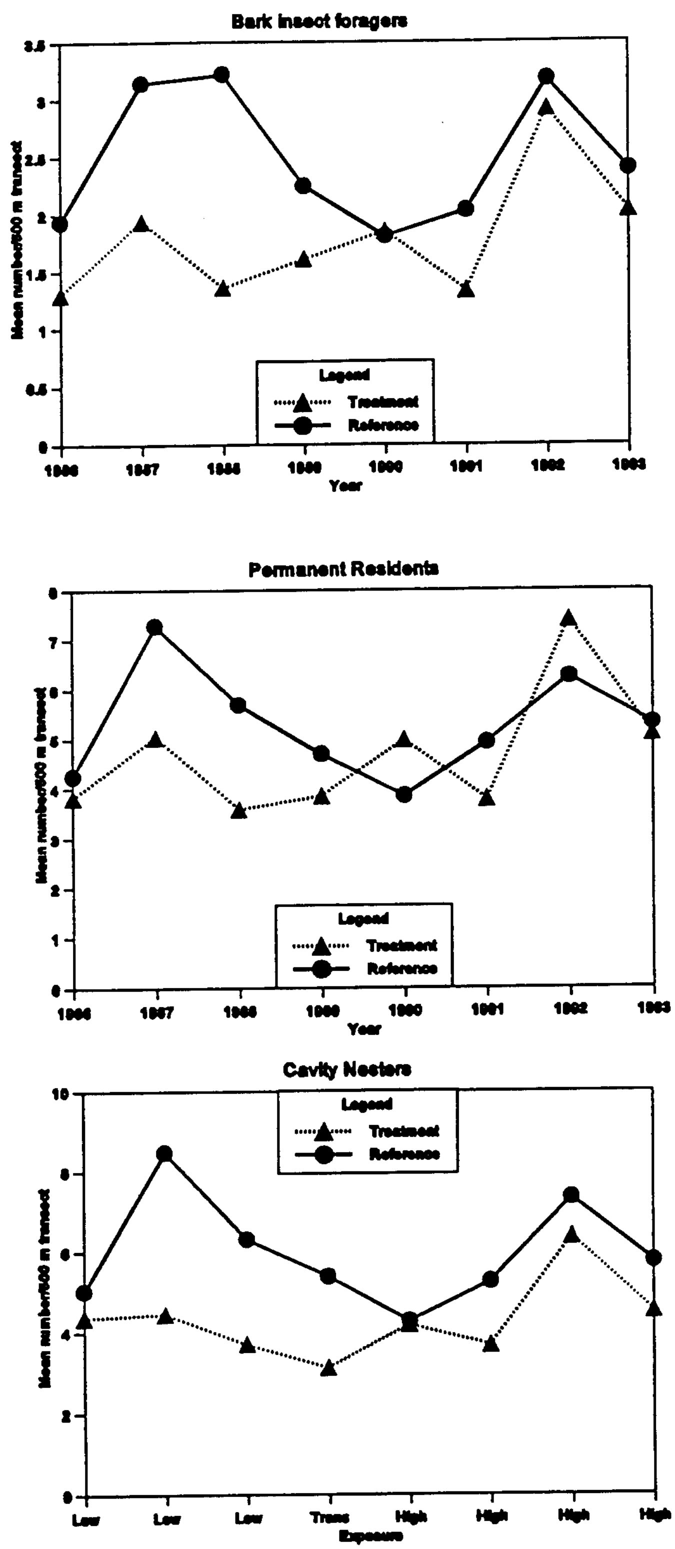

Figure 19. Mean number/500 m transect of cavity nesters, bark foragers, and permanent resident birds during the breeding season on reference and treatment study areas from 1986 to 1993.

If we examine species that showed a significant interaction in abundance in any season (8 total), all showed a significant interaction during one of the contrast periods. However, no pattern was evident for any season or contrast period to indicate a negative effect of EM field exposure. In addition, a similar proportion of changes in relative abundance was noted for species in each group both before and after antenna operation reached full strength (Figure 20).

Most species that indicated a significant interaction in abundance among reference and treatment areas over time were rare to uncommon in the study areas; most had means < 1 individual/500 m transect (including American Woodcock, Great Crested Flycatcher, Chipping Sparrow, Song Sparrow, Rose-breasted Grosbeak, and Black-and-white Warbler). Because of their low abundance, a rather small shift in relative abundance in treatment and reference areas from year to year would indicate a significant interaction in the repeated measures ANOVA (the test is most sensitive to changes in relative abundance).

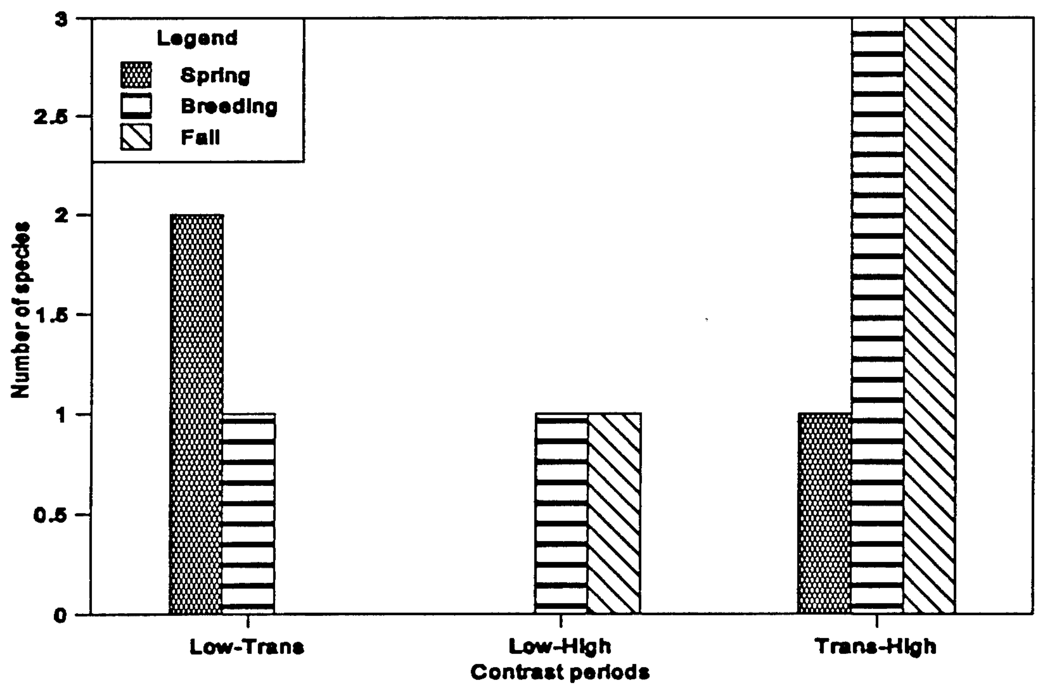

Figure 20. Number of species that indicated a significant contrast for three different exposure periods for the spring, breeding, and fall migration periods.

EM fields. Growth or navigational abilities of birds exposed to the ELF antenna could be affected by EM fields and are being studied in association with the Michigan antenna using Tree Swallows (Beaver et al., 1990). Many birds use the earth's magnetic field as an aid in navigation during migration (Wiltschko and Wiltschko, 1988),and Larkin and Sutherland (1979) observed that birds flying over the antenna (in Wisconsin) changed course more often than treatment individuals. Similarly, weak EM fields can cause

disorientation in homing pigeons (Wiltschko and Wiltschko, 1988). Although individuals in homing experiments were momentarily disoriented, all were able to adjust to EM field anomalies and successfully navigate.

Although a few significant differences were found at all levels of the analyses, no consistent differences in overall bird abundance between reference and treatment areas were detected during fall or spring migration, suggesting that birds were not attracted to or repelled by the antenna. More importantly, the majority of species and groups tested showed no effect. Close examination of abundance patterns of the parameters that were significant over time do not provide a convincing pattern of either a positive or negative effect. Many significant results could be attributed to spurious correlations due to the large number of species and groups that we examined and the great power of the test.

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Appendix 1. Scientific name, nesting, feeding, habitat, and migration classification for bird species observed in Michigan (1985-1993).

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Appendix 1. Scientific name, nesting, feeding, habitat, and migration classification for bird species observed in Michigan (1985-1993).

Species	Nest	Food	Habitat	Migration
Common Loon Gavia immer	1	1	9	2
Pied-billed Grebe Podilymbus podiceps	1	1	9	2
American Bittern Botaurus lentiginosus	3	1	6	2
Least Bittern Ixobrychus exilis	1	1	8	3
Great Blue Heron Ardea herodias	2	1	9	2
Canada Goose Branta canadensis	1	18	9	2
Wood Duck Aix sponsa	4	18	9	2
Mallard Anas platyrhynchos	1	18	9	2
Blue-winged Teal Anas discors	1	18	9	3
Hooded Merganser Lophodytes cucullatus	4	1	9	1
Red-breasted Merganser Mergus serrator	1	1	9	2
Turkey Vulture Cathartes aura	1	3	3	2

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Bald Eagle Haliaeetus leucocephalus	2	1	9	2
Northern Harrier Circus cyaneus	1	2	5	2
Sharp-shinned Hawk Accipiter striatus	2	2	2	2
Cooper's Hawk Accipiter cooperii	2	2	1	2
Northern Goshawk Accipiter gentilis	2	2	2	1
Broad-winged Hawk Buteo platypterus	2	2	3	3
Red-tailed Hawk Buteo jamaicensis	2	2	5	2
American Kestrel Falco sparverius	4	2	5	2
Merlin Falco columbarius	2	2	2	3
Spruce Grouse Dendragapus canadensis	1	4	2	1
Ruffed Grouse Bonasa umbellus	1	4	1	1
Virginia Rail Rallus limicola	3	19	8	2
Sora Porzana carolina	3	19	8	2

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Sandhill Crane <u>Grus canadensis</u>	1	5	8	2
Killdeer <u>Charadrius vociferus</u>	1	19	5	2
Greater Yellowlegs <u>Tringa melanoleuca</u>	1	1	10	3
Solitary Sandpiper <u>Tringa solitaria</u>	2	19	9	3
Spotted Sandpiper <u>Actitis macularia</u>	1	19	9	2
Common Snipe <u>Gallinago gallinago</u>	1	19	8	2
American Woodcock <u>Scolopax minor</u>	1	6	6	2
Mourning Dove <u>Zenaida macroura</u>	2	7	5	2
Black-billed Cuckoo <u>Coccyzus erythropthalmus</u>	3	10	1	3
Yellow-billed Cuckoo <u>Coccyzus americanus</u>	3	10	1	3
Barred Owl <u>Strix varia</u>	2	2	1	1
Common Nighthawk <u>Chordeiles minor</u>	1	11	3	3
Whip-poor-will <u>Caprimulgus vociferus</u>	1	11	1	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Chimney Swift Chaetura pelagica	4	11	7	3
Ruby-throated Hummingbird Archilochus colubris	2	17	9	3
Belted Kingfisher Ceryle alcyon	4	1	9	2
Yellow-bellied Sapsucker Sphyrapicus varius	4	17	1	2
Downy Woodpecker Picoides pubescens	4	16	1	1
Hairy Woodpecker Picoides villosus	4	16	1	1
Black-backed Woodpecker Picoides arcticus	4	16	2	1
Northern Flicker Colaptes auratus	4	9	5	2
Pileated Woodpecker Dryocopus pileatus	4	16	1	1
Olive-sided Flycatcher Contopus borealis	2	12	4	3
Eastern Wood-Pewee Contopus virens	2	12	3	3
Yellow-bellied Flycatcher Empidonax flaviventris	1	12	11	3
Alder Flycatcher Empidonax alnorum	3	12	6	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Least Flycatcher Empidonax minimus	3	12	1	3
Eastern Phoebe Sayornis phoebe	5	12	9	2
Great Crested Flycatcher Myiarchus crinitus	4	12	1	3
Eastern Kingbird Tyrannus tyrannus	2	12	5	3
Tree Swallow Tachycineta bicolor	4	11	5	2
Barn Swallow Hirundo rustica	5	11	7	3
Gray Jay Perisoreus canadensis	2	5	11	1
Blue Jay Cyanocitta cristata	2	5	1	1
American Crow Corvus brachyrhynchos	2	5		2
Common Raven Corvus corax	2	5	2	1
Black-capped Chickadee Parus atricapillus	4	10	1	1
Boreal Chickadee Parus hudsonicus	4	10	11	1
Red-breasted Nuthatch Sitta canadensis	4	16	2	1

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
White-breasted Nuthatch Sitta carolinensis	4	16	1	1
Brown Creeper Certhia americana	4	16	1	2
House Wren Troglodytes aedon	4	10	7	3
Winter Wren Troglodytes troglodytes	1	10	11	2
Sedge Wren Cistothorus platensis	3	10	8	2
Marsh Wren Cistothorus palustris	3	10	8	2
Golden-crowned Kinglet Regulus satrapa	2	10	2	2
Ruby-crowned Kinglet Regulus calendula	2	10	2	2
Blue-gray Gnatcatcher Polioptila caerulea	3	10	1	3
Eastern Bluebird Sialia sialis	4	12	5	2
Veery Catharus fuscescens	1	9	1	3
Gray-cheeked Thrush Catharus minimus	3	9	4	3
Swainson's Thrush Catharus ustulatus	2	9	11	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Hermit Thrush _Catharus guttatus_	1	9	3	2
Wood Thrush _Hylocichla mustelina_	3	9	1	3
American Robin _Turdus migratorius_	2	9	5	2
Gray Catbird _Dumetella carolinensis_	3	13	4	3
Brown Thrasher _Toxostoma rufum_	3	9	4	2
Cedar Waxwing _Bombycilla cedrorum_	2	14	9	1
European Starling _Sturna vulgaris_	4	9	7	1
Solitary Vireo _Vireo solitarius_	2	10	2	3
Yellow-throated Vireo _Vireo flavifrons_	2	10	1	3
Warbling Vireo _Vireo gilvus_	2	10	1	3
Philadelphia Vireo _Vireo philadelphicus_	2	10	1	3
Red-eyed Vireo _Vireo olivaceus_	2	10	1	3
Golden-winged Warbler _Vermivora chrysoptera_	1	10	4	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Tennessee Warbler <u>Vermivora peregrina</u>	1	10	11	3
Nashville Warbler <u>Vermivora ruficapilla</u>	1	10	11	3
Northern Parula <u>Parula americana</u>	2	10	11	3
Yellow Warbler <u>Dendroica petechia</u>	3	10	6	3
Chestnut-sided Warbler <u>Dendroica pensylvanica</u>	3	10	4	3
Magnolia Warbler <u>Dendroica magnolia</u>	2	10	2	3
Cape May Warbler <u>Dendroica tigrina</u>	2	10	2	3
Black-throated Blue Warbler <u>Dendroica caerulescens</u>	3	10	1	3
Yellow-rumped Warbler <u>Dendroica coronata</u>	2	13	2	2
Black-throated Green Warbler <u>Dendroica virens</u>	2	10	3	3
Blackburnian Warbler <u>Dendroica fusca</u>	2	10	2	3
Pine Warbler <u>Dendroica pinus</u>	2	10	2	2
Palm Warbler <u>Dendroica palmarum</u>	1	10	11	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Bay-breasted Warbler <u>Dendroica castanea</u>	2	10	2	3
Blackpoll Warbler <u>Dendroica striata</u>	2	10	2	3
Black-and-white Warbler <u>Mniotilta varia</u>	1	16	3	3
American Redstart <u>Setophaga ruticilla</u>	2	12	4	3
Ovenbird <u>Seiurus aurocapillus</u>	1	10	1	3
Northern Waterthrush <u>Seiurus noveboracensis</u>	1	10	9	3
Connecticut Warbler <u>Oporornis agilis</u>	1	10	11	3
Mourning Warbler <u>Oporornis philadelphia</u>	1	10	4	3
Common Yellowthroat <u>Geothylpis trichas</u>	3	10	6	3
Wilson's Warbler <u>Wilsonia pusilla</u>	3	10	6	3
Canada Warbler <u>Wilsonia canadensis</u>	3	10	3	3
Scarlet Tanager <u>Piranga olivacea</u>	2	10	1	3
Rose-breasted Grosbeak <u>Pheucticus ludovicianus</u>	3	13	1	3

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Indigo Bunting *Passerina cyanea*	3	15	5	3
Rufous-sided Towhee *Pipilo erythrophthalmus*	1	8	4	2
Chipping Sparrow *Spizella passerina*	2	8	2	2
Clay-colored Sparrow *Spizella pallida*	3	8	5	2
Vesper Sparrow *Pooecetes gramineus*	1	8	5	2
Savannah Sparrow *Passerculus sandwichensis*	1	8	5	2
Le Conte's Sparrow *Ammodramus leconteii*	1	8	8	2
Song Sparrow *Melospiza melodia*	3	8	5	2
Lincoln's Sparrow *Melospiza lincolnii*	1	8	11	3
Swamp Sparrow *Melospza georgianna*	3	8	6	2
White-throated Sparrow *Zonotrichia albicollis*	1	8	4	2
Dark-eyed Junco *Junco hyemalis*	1	8	11	2
Red-winged blackbird *Agelaius phoeniceus*	3	8	8	2

Appendix 1 (continued)

Species	Nest	Food	Habitat	Migration
Rusty Blackbird *Euphagus carolinus*	3	8	9	2
Brewer's Blackbird *Euphagus cyanocephalus*	3	8	5	2
Common Grackle *Quiscalus quiscula*	3	5	5	2
Brown-headed Cowbird *Molothrus ater*	7	8	5	2
Northern Oriole *Icterus galbula*	2	13	1	3
Purple Finch *Carpodacus purpureus*	2	7	3	2
Red Crossbill *Loxia curvirostra*	2	7	2	1
White-winged Crossbill *Loxia leucoptera*	2	7	2	1
Pine Siskin *Carduelis pinus*	2	15	2	1
American Goldfinch *Carduelis tristis*	3	7	5	2
Evening Grosbeak *Coccothraustes vespertinus*	2	15	3	1
Unidentified woodpecker	4			

Appendix 1 (continued)

A. Nesting

1 Ground

2 Canopy or canopy vegetation (tree but not necessarily tree top)

3 Subcanopy or shrub

4 Cavity, hole or bank

5 Ledge or platform

6 Cavity - tree roots

7 Nest parasite

B. Food

1 Aquatic vertebrates, including fish or other aquatic vertebrates

2 Birds, small mammals, large insects

3 Carrion

4 Vegetation such as buds, pine needles, and seeds but excluding species concentrating on seeds or fruits

5 Various small vertebrates (including eggs and young), invertebrates, plants, carrion, etc. (e.g., Omnivores)

6 Ground invertebrates

7 Seeds (plus a smaller amount of fruit by some species)

8 Ground invertebrates and seeds

9 Ground invertebrates and fruit

10 Foliage invertebrates

11 Aerial insects - taken while in continuous flight

12 Aerial insects - taken in sallies from a perch

13 Foliage invertebrates and fruit

14 Fruit

15 Foliage invertebrates and seeds

16 Bark insects

17 Nectar and sap

18 Aquatic vegetation

19 Aquatic invertebrates

C. Habitat

1 Deciduous forest

2 Coniferous forest

3 Mixed deciduous - coniferous forest

4 Early successional deciduous - coniferous forest

5 Fields and meadows

6 Shrub swamp

7 Urban

8 Open wetlands (e.g., sedge fen, cattail)

9 Ponds, lakes, rivers, and streams

10 Muskeg

11 Lowland coniferous forest

D. Migration

1 Permanent resident; populations may be augmented during winter or during summer

2 Short-distance migrant; generally includes breeders; individuals generally winter south of study areas but most winter north of the tropics

3 Long-distance migrant; generally winter south of the U.S.

4 Winter resident

Appendix 2. Number of individuals and species observed on control and treatment transects in Michigan during May in 1986-1993 on transects used in the final statistical analyses (36 control and 33 treatment).

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Appendix 2. Number of individuals and species observed on reference and treatment transects in Michigan during May in 1986-1993 on transects used in the final statistical analyses (36 reference and 33 treatment).

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Common Loon									0	1						
Pied-billed Grebe															0	1
American Bittern			1	1	1	1					1	1	0	2		
Great Blue Heron	0	1											0	1		
Canada Goose					0	2	0	1	0	1	0	2			0	4
Wood Duck					0	1	0	5	0	1			2	0	0	6
Mallard	1	0			0	1	1	1			1	4	0	4	0	1
Blue-winged Teal			0	4							0	2				
Hooded Merganser					0	2	0	3					0	3		
Turkey Vulture					2	0	2	0								
Bald Eagle							0	1								

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Sharp-shinned Hawk					1	0					0	1	0	1		
Northern Goshawk													1	0		
Broad-winged Hawk	0	1	2	3	3	1			1	3	0	2	2	0	1	0
Red-tailed Hawk					0	2							0	1		
American Kestrel	1	0					0	2	2	0	1	2	2	1	1	0
Spruce Grouse	1	0														
Ruffed Grouse	9	7	12	4	16	17	23	13	16	11	17	10	6	8	12	16
Virginia Rail											0	1				
Sandhill Crane											0	1				
Killdeer			0	2					1	0			1	0		
Greater Yellowlegs											0	1				
Common Snipe			0	1	1	4			0	1	1	0			1	1

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
American Woodcock	2	0	0	1	0	1	1	1	5	1	1	0	0	3	2	0
Mourning Dove					0	1					1	0				
Black-billed Cuckoo															1	0
Barred Owl			1	0					0	1						
Whip-poor-will	1	1					0	1								
Belted Kingfisher	0	1	0	1	0	1	0	1								
Yellow-bellied Sapsucker	10	21	12	25	21	55	13	46	15	27	19	42	11	27	13	20
Downy Woodpecker	6	9	1	7	10	8	7	7	3	2	3	7	7	7	0	4
Hairy Woodpecker	7	4	2	2	3	1	2	4	4	5	2	5	3	4	2	6
Black-backed Woodpecker	0	1					1	0			1	0				
Northern Flicker	23	31	15	18	24	28	25	14	10	10	17	14	11	3	19	23
Pileated Woodpecker	1	0	1	1	1	0	1	0	1	3	0	2	4	3	4	3

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Olive-sided Flycatcher	1	0									0	1	0	1		
Eastern Wood-Pewee									1	0	0	1				
Yellow-bellied Flycatcher					1	1			1	1			0	2		
Alder Flycatcher									1	0						
Least Flycatcher	16	42	4	13	13	14			30	28	2	37	40	67	4	7
Eastern Phoebe	1	1	1	1			1	2	2	0	1	1	1	0	4	0
Great Crested Flycatcher	4	6	1	3	1	7	0	2	3	7	1	5	2	12	1	2
Eastern Kingbird	0	2	0	1												
Tree Swallow	0	11	0	9	2	15	1	0	1	8	0	5	0	2	0	2
Gray Jay					3	2	2	0	2	7	2	0	2	1	4	0
Blue Jay	53	58	27	30	21	40	16	11	15	23	24	18	32	15	35	25
American Crow	0	2			2	1	1	0	1	2	1	0			0	1

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Common Raven	0	2	0	3	10	5	2	2	1	3	1	4	5	2	4	1
Black-capped Chickadee	23	26	15	48	56	66	68	75	44	63	50	39	47	71	77	87
Boreal Chickadee	5	0	2	0	2	0	5	0	2	0	6	4	5	2	2	0
Red-breasted Nuthatch	11	8	8	11	32	29	10	10	20	25	3	5	25	24	26	29
White-breasted Nuthatch	3	4	3	2	5	14	1	4	5	4	2	3	1	4	2	2
Brown Creeper	2	10	1	8	1	15	16	35	3	16	9	27	8	11	18	20
House Wren											1	0	1	1		
Winter Wren	15	32	23	27	31	42	13	25	14	23	17	37	20	32	21	41
Sedge Wren	1	6							0	1	0	2	1	8	0	2
Marsh Wren							0	2								
Golden-crowned Kinglet	42	20	58	44	61	67	59	39	42	39	46	36	45	13	11	14
Ruby-crowned Kinglet	10	8	7	7	23	9	24	35	12	11	19	9	11	6	60	60

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Blue-gray Gnatcatcher									0	1						
Eastern Bluebird							1	0							1	0
Veery									0	1	2	0	1	0	0	1
Gray-cheeked Thrush													2	0		
Swainson's Thrush					1	0							3	1		
Hermit Thrush	19	26	18	25	43	38	41	31	32	16	18	27	29	22	48	45
Wood Thrush	1	1	0	1							0	6	5	0		
American Robin	38	42	24	26	48	49	29	39	28	23	29	21	18	27	46	29
Gray Catbird			0	1					0	1					1	1
Brown Thrasher	5	1	3	0			4	0	4	1	8	0	3	0	5	1
Cedar Waxwing	0	1														
European Starling	0	3	1	7	3	4	1	4								

Appendix 2 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Solitary Vireo	6	2	8	6	6	2	0	2	9	5	5	9	8	10	3	4
Yellow-throated Vireo	0	1							1	1					0	4
Red-eyed Vireo	8	8	1	6	0	1			3	1	1	0	14	4	1	2
Golden-winged Warbler	3	10	4	1					6	0	2	2	4	1		
Tennessee Warbler	0	2			0	2							2	2	1	0
Nashville Warbler	215	208	179	123	58	74	0	1	90	79	44	47	152	127	43	31
Northern Parula	0	10	0	11					1	7	1	11	3	21	2	1
Yellow Warbler					1	0			2	0						
Chestnut-sided Warbler	7	12	2	3					12	2	4	4	15	13	1	0
Magnolia Warbler	2	10											2	7	0	3
Cape May Warbler	0	5											1	0		
Black-throated Blue Warbler	0	2													0	1

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Yellow-rumped Warbler	62	37	59	45	67	42	43	39	65	48	47	40	65	45	33	29
Black-throated Green Warb.	75	97	18	57	15	39	0	1	24	55	14	57	65	87	23	51
Blackburnian Warbler			1	0					4	0	0	8	3	6	0	2
Pine Warbler	0	1	4	2							1	0	1	0		
Palm Warbler	6	4	2	2			1	0	1	2	2	2	0	4	2	4
Bay-breasted Warbler			0	1					1	0			1	5		
Black-and-white Warbler	17	34	2	13	3	15			24	30	8	16	16	27	2	8
American Redstart													0	3		
Ovenbird	55	100	9	28	1	14			69	55	37	60	102	116	34	36
Northern Waterthrush	0	5	0	4			0	2	0	3	4	3	2	6	1	5
Connecticut Warbler	0	1			0	1			1	3						
Mourning Warbler	1	1			1	0										

Appendix 2 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Common Yellowthroat	3	1							4	2			6	6	0	1
Wilson's Warbler													0	1		
Canada Warbler					1	0										
Scarlet Tanager	1	1							0	1	1	6	4	1		
Rose-breasted Grosbeak	2	36	5	9	1	1			13	15	10	17	35	27	2	8
Indigo Bunting													0	1		
Rufous-sided Towhee	5	3	6	2	0	1	2	0	10	2	4	5	5	3	1	0
Chipping Sparrow	11	30	30	20	24	17	7	13	10	5	5	18	14	18	8	6
Clay-colored Sparrow					0	1										
Vesper Sparrow			0	3			2	0	1	0						
Savannah Sparrow															0	1
Le Conte's Sparrow					1	0										

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Song Sparrow	5	7	13	11	23	6	15	16	22	3	0	9	14	9	11	10
Lincoln's Sparrow									0	1			1	0	3	0
Swamp Sparrow	18	11	10	21	10	19	5	9	7	11	9	10	12	11	10	18
White-throated Sparrow	85	55	111	48	91	57	58	35	91	50	54	23	95	50	95	55
Dark-eyed Junco	0	1	6	6	6	0	13	1	10	0	2	0	3	2	13	1
Red-winged blackbird	0	41	10	38	4	30	0	12	2	24	0	10	2	9	0	11
Rusty Blackbird			0	2			0	1								
Common Grackle	1	5	0	9	5	8	9	11	3	12	4	5	5	1		
Brown-headed Cowbird	8	20	3	10	4	11	9	18	4	11	1	4	1	4	4	10
Northern Oriole	0	4	2	1					0	1	0	1	0	1		
Purple Finch	13	18	17	30	9	15	21	20	9	8	2	10	6	3	7	6
Red Crossbill							1	0							0	1

Appendix 2 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
White-winged Crossbill									2	0					8	10
Pine Siskin	0	1	1	0	4	7	0	4	1	1					6	5
American Goldfinch	2	6	1	1			1	0	3	2	0	2	1	7	5	5
Evening Grosbeak	2	7	0	2	6	2	4	1	4	17	0	2				
Unidentified non-passerine	24	24	21	22	21	20	7	5	11	17	8	10	26	25	43	47
Unidentified sparrow													1	0		
Unidentified woodpecker			7	14	11	9	1	0	5	13	1	2	1	5	6	5
Unidentified passerine					0	1									1	0
Total individuals	949	1210	775	888	815	939	570	607	847	858	578	778	1045	1060	795	836
Total number species	54	69	50	62	53	56	44	46	65	65	55	62	66	69	54	59

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Appendix 3. Numbers of individuals and species observed on control and treatment transects in Michigan during the breeding season 1986-1993 on transects used in the final statistical analyses (36 control and 33 treatment).

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Appendix 3. Numbers of individuals and species observed on reference and treatment transects in Michigan during the breeding season 1986-1993 on transects used in the final statistical analyses (36 reference and 33 treatment).

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Pied-billed Grebe					0	2			0	1	0	1				
American Bittern															0	2
Least Bittern					1	0										
Great Blue Heron	0	1	0	1											0	2
Wood Duck							0	2	2	1	0	3	0	2		
Mallard	0	1	11	0	0	2										
Blue-winged Teal					1	0										
Red-breasted Merganser													0	6		
Turkey Vulture									1	0						
Northern Harrier			0	1	1	0										
Sharp-shinned Hawk					0	1	0	2	1	1	0	2	2	2	0	1

Appendix 3 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Cooper's Hawk					1	0										
Northern Goshawk					1	0					1	0				
Broad-winged Hawk	3	4	3	2	1	1	0	3	2	4	2	2	2	2	2	1
Red-tailed Hawk	1	0			0	1	0	1	2	0			0	2		
American Kestrel	1	0					2	2	2	1	5	2			4	0
Merlin															1	0
Ruffed Grouse	9	26	6	4	6	26	13	15	8	15	6	15	6	10	9	2
Sora					0	2										
Sandhill Crane											0	2				
Killdeer			1	0	1	0					0	1				
Spotted Sandpiper											0	1				
Common Snipe	0	1	1	0	0	2										

Appendix 3 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
American Woodcock	2	7	5	12	5	4	7	3	4	2	2	6	1	2	4	2
Mourning Dove					0	2					0	1				
Black-billed Cuckoo			1	1	2	3	1	0	0	1	2	0	4	1		
Yellow-billed Cuckoo			1	1			1	4	0	1			0	1		
Barred Owl			0	3	0	1									0	2
Common Nighthawk	0	1	0	2	0	1							1	0	2	0
Whip-poor-will	1	1			1	0										
Chimney Swift			0	1			0	2					0	2		
Ruby-throated Hummingbird	1	0	3	2			1	2	2	5	1	4	0	2	2	2
Belted Kingfisher	0	3			0	2	0	1	4	2	0	1			0	2
Yellow-bellied Sapsucker	22	22	13	36	14	34	12	26	6	26	12	33	12	36	5	30
Downy Woodpecker	11	16	9	18	6	11	6	3	4	6	1	11	6	13	5	9

Appendix 3 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Hairy Woodpecker	4	4	1	11	2	8	6	4	7	5	9	7	6	8	8	10
Black-backed Woodpecker	1	0			1	0	0	3	2	1	1	0	2	0	4	0
Northern Flicker	29	33	13	13	24	15	18	15	28	14	14	7	17	11	12	9
Pileated Woodpecker	0	2	3	1	0	1	2	4	1	2	1	2	3	2	2	2
Olive-sided Flycatcher	5	1	4	6	1	1	3	2			0	1	4	0	1	3
Eastern Wood-Pewee	9	20	14	19	9	14	10	24	16	20	12	17	13	20	14	12
Yellow-bellied Flycatcher	33	16	20	10	24	14	22	12	23	8	22	14	28	18	18	9
Alder Flycatcher	9	12	14	11	14	11	9	12	10	7	13	5	11	7	4	7
Least Flycatcher	28	74	49	63	32	52	36	47	37	51	13	58	14	39	21	27
Eastern Phoebe	0	1	2	1	1	0			1	0	0	1	2	0	2	1
Great Crested Flycatcher	14	27	16	36	13	22	4	31	5	22	14	16	7	25	10	14
Eastern Kingbird	8	7	3	9	6	3	4	2	2	6	4	3	4	3	0	2

Appendix 3 (continued)

Species	1986 T	1986 R	1987 T	1987 R	1988 T	1988 R	1989 T	1989 R	1990 T	1990 R	1991 T	1991 R	1992 T	1992 R	1993 T	1993 R
Tree Swallow	1	1	8	7	0	2			4	0			1	0	0	1
Gray Jay	1	0	8	6	1	3	9	2	10	5	2	6	5	0	16	8
Blue Jay	37	29	52	59	33	41	32	26	41	29	26	26	40	36	27	33
American Crow	11	0	12	5	6	3	2	0			2	0	2	4		
Common Raven	1	5	10	14	2	2	2	5	3	6	2	3	5	10	4	7
Black-capped Chickadee	54	61	63	112	42	73	40	68	61	57	55	92	94	109	71	80
Boreal Chickadee	7	0	1	0	4	0	6	1	3	0	3	1	11	1	9	1
Red-breasted Nuthatch	15	9	17	25	27	37	21	32	28	11	13	14	62	36	26	25
White-breasted Nuthatch	0	6	9	8	0	3	0	1	1	7	4	7	3	5	7	6
Brown Creeper	4	9	12	22	9	26	8	17	5	10	9	18	18	20	12	24
House Wren			0	2	3	0			0	2	1	4	1	5	0	3
Winter Wren	23	31	40	46	20	42	22	39	23	23	21	43	21	29	30	56

Appendix 3 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Sedge Wren	5	6	2	2	8	6	5	3	1	13	1	9	2	6	1	5
Marsh Wren					4	3							1	0		
Golden-crowned Kinglet	53	37	90	43	64	48	56	35	48	38	71	57	64	25	61	55
Ruby-crowned Kinglet	1	6	2	2	8	1	7	2	6	3	5	2	9	0	4	1
Eastern Bluebird			6	2	5	1	2	1	1	0	3	2			2	0
Veery	27	26	34	42	24	30	28	32	15	17	16	23	21	28	15	9
Swainson's Thrush	0	1			0	3	0	2	0	1						
Hermit Thrush	82	50	79	71	72	64	97	95	70	72	85	74	76	85	81	70
Wood Thrush	4	4	2	5	3	9	2	1	0	6	0	9			2	3
American Robin	45	43	54	45	47	23	32	35	16	26	36	30	29	27	25	33
Gray Catbird	0	1	1	5	2	0	2	1	1	0						
Brown Thrasher	5	0	5	1	6	0	8	2	8	0	7	1	4	0	3	2

Appendix 3 (continued)

Species	1986 T	1986 R	1987 T	1987 R	1988 T	1988 R	1989 T	1989 R	1990 T	1990 R	1991 T	1991 R	1992 T	1992 R	1993 T	1993 R
Cedar Waxwing	12	11	13	14	29	21	33	17	22	8	31	23	33	16	24	19
European Starling	0	2	0	6			2	0	1	0			1	0	1	0
Solitary Vireo	3	6	4	2	8	6	12	3	7	7	8	12	11	15	8	6
Yellow-throated Vireo	0	2	0	2	1	1	1	2			2	3	2	2	1	5
Warbling Vireo	0	2														
Philadelphia Vireo	0	1			1	0	1	0					1	0		
Red-eyed Vireo	116	136	108	122	78	90	75	90	74	117	103	112	117	153	85	119
Golden-winged Warbler	7	5	17	5	19	8	7	11	7	5	6	2	2	2	1	2
Tennessee Warbler	1	2	3	5	5	1	0	2								
Nashville Warbler	153	82	156	78	117	89	140	90	119	96	143	102	170	129	182	112
Northern Parula	8	19	12	18	7	23	8	13	7	16	3	11	3	13	2	15
Yellow Warbler	1	0	1	3	1	2	0	1			0	5			0	1

Appendix 3 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Chestnut-sided Warbler	71	51	78	46	75	28	64	42	58	37	59	22	53	33	47	15
Magnolia Warbler	1	3			1	2	3	0	1	1	6	1	3	5	5	9
Cape May Warbler	1	7	4	5	1	1			2	1			5	2	1	3
Black-throated Blue Warbler	1	1	0	1	0	1	0	2	0	1					1	0
Yellow-rumped Warbler	24	17	24	14	33	19	30	25	20	31	24	25	50	24	40	39
Black-throated Green Warb.	68	81	56	89	54	62	45	75	45	75	56	70	75	97	57	109
Blackburnian Warbler	9	11	3	17	6	18	12	13	10	12	4	11	10	20	4	18
Pine Warbler			2	3	2	1	4	1	1	0	1	1	0	1	1	0
Palm Warbler			2	0			1	0			3	2				
Bay-breasted Warbler	0	2											1	1	3	1
Blackpoll Warbler			1	0												
Black-and-white Warbler	20	26	30	38	20	37	23	29	24	28	17	24	21	40	16	18

Appendix 3 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
American Redstart	2	0	1	1	2	3	0	1	0	1			2	1		
Ovenbird	195	214	161	183	137	145	140	188	115	135	129	164	170	200	150	166
Northern Waterthrush	1	1	0	3	0	2	0	8	0	3			0	1	0	3
Connecticut Warbler	5	1	6	0	3	2	2	0	2	0						
Mourning Warbler	20	19	28	25	29	19	38	16	25	21	22	28	17	18	21	17
Common Yellowthroat	9	38	26	33	15	24	13	30	18	23	23	37	21	42	24	41
Canada Warbler	3	8	4	3	0	1	4	11	2	2	1	6	9	9	5	8
Scarlet Tanager	9	16	11	12	6	17	15	19	12	14	12	20	11	20	16	18
Rose-breasted Grosbeak	34	57	28	30	38	47	25	43	26	40	14	47	34	39	6	16
Indigo Bunting	19	20	9	15	16	18	30	22	23	31	26	36	30	20	18	16
Rufous-sided Towhee	7	10	7	2	11	7	14	5	5	3	10	4	9	5	5	2
Chipping Sparrow	26	25	17	17	33	13	30	11	19	11	7	13	13	18	32	18

Appendix 3 (continued)

Species	1986 T	1986 R	1987 T	1987 R	1988 T	1988 R	1989 T	1989 R	1990 T	1990 R	1991 T	1991 R	1992 T	1992 R	1993 T	1993 R
Clay-colored Sparrow					0	1										
Vesper Sparrow			0	2			2	0	1	1	1	0				
Song Sparrow	16	31	18	28	17	13	22	20	15	8	14	22	15	26	15	31
Lincoln's Sparrow	1	2									1	0			1	0
Swamp Sparrow	15	24	15	27	7	15	8	17	8	17	11	24	10	13	9	23
White-throated Sparrow	95	59	115	49	94	46	95	57	82	32	59	30	57	30	57	45
Dark-eyed Junco	0	2	0	3	12	0	6	0	6	0	2	0	3	0		
Red-winged blackbird	7	34	8	34	3	19	1	22	1	12	3	6	2	9	0	6
Brewer's Blackbird											0	2				
Common Grackle	0	14	7	18	2	9	4	8	4	5	23	7	4	5	4	2
Brown-headed Cowbird	2	10	3	10	1	11	3	7	2	8	2	9	0	1	0	3
Northern Oriole	0	3	0	5	0	3	4	4	1	1	2	2	0	3	0	2

Appendix 3 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Purple Finch	8	9	2	5	0	5	4	4	2	7	4	4	3	3	6	1
White-winged Crossbill							37	0	2	3			16	0		
American Goldfinch	5	2	10	6	3	3	7	3	9	9	5	3	10	8	9	13
Evening Grosbeak			4	2	6	4	0	4			1	0	0	1		
Unidentified non-passerine	55	51	70	56	33	30	40	29	28	24	30	27	22	27	26	15
Unidentified sparrow	0	10	1	0	1	0										
Unidentified thrush			1	0												
Unidentified woodpecker	7	2	10	23	9	15	7	6	3	4	6	3	8	8	3	6
Unidentified vireo			0	1												
Unidentified passerine			0	1												
Total individuals	1604	1734	1776	1850	1494	1538	1550	1573	1324	1378	1371	1557	1638	1700	1412	1516
Total number species	73	81	80	86	82	87	76	81	79	76	75	80	76	74	72	76

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Appendix 4. Number of individuals and species observed on control and treatment transects in Michigan during the fall migration season 1986-1993 on transects used in the final statistical analyses (36 control and 33 treatment).

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Appendix 4. Numbers of individuals and species observed on reference and treatment transects in Michigan during the fall migration season 1986-1993 on transects used in the final statistical analyses (36 and 33 treatment).

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Common Loon									0	1						
American Bittern											0	1				
Great Blue Heron					0	1										
Wood Duck					0	2	0	1			0	3			0	3
Mallard	0	9											0	2		
Turkey Vulture													0	2		
Northern Harrier							0	1								
Sharp-shinned Hawk			0	1	2	0	1	2	0	2	0	2	0	1	3	0
Cooper's Hawk			1	0												
Broad-winged Hawk	5	3	2	2	4	2	0	1	0	4	5	0	3	4	1	0
Red-tailed Hawk	2	0	1	0	1	1	3	0			1	1	0	1		

Appendix 4 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
American Kestrel			2	0	5	0	3	0	1	1	6	0			1	0
Merlin											0	1	0	2		
Spruce Grouse							0	1								
Ruffed Grouse	15	24	18	10	17	13	25	7	3	18	11	11	6	12	3	9
Sandhill Crane	1	0			0	2										
Solitary Sandpiper	0	2														
Spotted Sandpiper											0	1				
American Woodcock	4	0	9	5	13	1	8	5	2	4	2	3	3	1	2	4
Mourning Dove													1	0		
Black-billed Cuckoo			0	1							0	1			0	1
Yellow-billed Cuckoo											0	1	1	1		
Barred Owl	1	0					0	1					1	1		

Appendix 4 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Common Nighthawk			1	0	0	3										
Whip-poor-will					1	0	1	0								
Ruby-throated Hummingbird	1	3					2	4	1	1						
Belted Kingfisher	1	1	2	2	1	4					1	1			2	0
Yellow-bellied Sapsucker	20	27	4	18	8	26	5	15	6	21	1	8	5	12	1	9
Downy Woodpecker	10	28	13	17	2	1	4	7	13	5	20	11	9	12	12	12
Hairy Woodpecker	7	9	6	10	18	9	6	10	6	8	12	5	9	10	7	8
Black-backed Woodpecker	2	6	1	2	2	2	2	2	1	2	0	1	2	0		
Northern Flicker	23	20	23	27	18	22	27	13	19	14	36	20	17	13	21	19
Pileated Woodpecker	2	5	2	3	2	9	4	0	2	8	3	14	3	6	2	2
Olive-sided Flycatcher					2	0	3	2			1	0			0	2
Eastern Wood-Pewee	12	17	9	25	15	18	11	28	13	17	8	15	14	16	11	15

Appendix 4 (continued)

Species	1986 T	1986 R	1987 T	1987 R	1988 T	1988 R	1989 T	1989 R	1990 T	1990 R	1991 T	1991 R	1992 T	1992 R	1993 T	1993 R
Yellow-bellied Flycatcher	1	4	6	2	3	3	1	0	0	1	2	2	1	0	2	0
Alder Flycatcher			2	1	0	1	6	6			5	1	4	5	3	0
Least Flycatcher			1	1	1	1	2	4	2	4	1	4	2	1	1	2
Eastern Phoebe	2	1	1	1	1	1	1	1	2	0			1	0	2	0
Great Crested Flycatcher	2	3	3	3	2	2	1	2	0	2	1	8	1	6	1	5
Eastern Kingbird	5	0	3	2	0	3	6	8	0	5	1	3	3	4	1	1
Barn Swallow															0	2
Gray Jay	10	10	12	3	5	7	13	8	11	9	6	11	9	9	8	5
Blue Jay	35	48	66	54	45	49	43	38	77	69	53	36	40	34	29	41
American Crow	1	1	9	2	2	1	0	1	0	4	0	1	1	2	0	2
Common Raven	1	8	4	9	0	6	2	4	3	2	4	0	1	2	1	1
Black-capped Chickadee	88	180	142	172	115	139	148	154	91	117	112	119	109	138	131	148

Appendix 4 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Boreal Chickadee	3	0	4	1	5	2	10	2	5	1	4	0	10	2	4	1
Red-breasted Nuthatch	28	29	65	76	45	61	104	76	22	30	82	59	66	62	24	24
White-breasted Nuthatch	3	5	3	13	5	5	3	8	3	13	2	16	4	17	18	16
Brown Creeper	6	23	31	35	34	36	14	25	2	7	14	21	17	24	24	43
House Wren									1	0	1	0				
Winter Wren	1	10	19	9	9	9	14	12	4	14	4	13	7	16	2	3
Sedge Wren	2	1	0	1	3	7	2	0	1	2	0	8	2	1		
Marsh Wren							0	1							0	1
Golden-crowned Kinglet	79	69	161	63	98	64	86	53	42	42	22	17	30	11	4	12
Ruby-crowned Kinglet	1	6	9	1	1	2	8	1	3	13	1	0	5	0	1	0
Eastern Bluebird			3	0					7	0	3	0	4	0		
Veery	0	2	2	2	3	1	3	0	0	1	1	2				

Appendix 4 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Gray-cheeked Thrush	1	1	3	0					1	0						
Swainson's Thrush	2	4	7	0	0	2			0	3	0	3				
Hermit Thrush	21	25	23	12	33	29	55	52	19	21	33	53	17	19	7	9
Wood Thrush			0	3	0	1					0	1	0	1		
American Robin	16	14	28	27	23	17	24	13	24	10	19	19	30	10	30	12
Gray Catbird			2	0	1	1	2	0	1	0						
Brown Thrasher	1	0	3	0			3	0	1	0						
Cedar Waxwing	7	16	38	39	69	20	42	15	4	9	92	53	9	2	17	21
European Starling							5	0								
Solitary Vireo			0	3	1	0	2	2	0	2	4	3	0	1	1	0
Yellow-throated Vireo					2	2							0	1	1	0
Red-eyed Vireo	15	21	23	24	11	16	38	49	45	57	50	58	31	38	29	38

Appendix 4 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Golden-winged Warbler			2	0	0	1										
Tennessee Warbler	5	13	2	0			2	0	3	2	1	0	1	1		
Nashville Warbler	8	25	14	6	6	16	21	14	16	22	5	5	9	2	3	4
Northern Parula			2	3			1	1	0	2	3	3				
Yellow Warbler					0	1	1	0			1	0				
Chestnut-sided Warbler	1	3	3	4	3	10	8	5			2	0	3	2	0	1
Magnolia Warbler	1	3			2	6	1	0	0	1					1	1
Cape May Warbler	2	0							2	0					1	0
Black-throated Blue Warbler	3	0	0	1			1	0					0	1		
Yellow-rumped Warbler	20	36	7	16	17	4	0	5	10	2	16	1	6	2	1	1
Black-throated Green Warb.	1	10	5	15	12	10	12	16	10	11	1	5	7	9	0	1
Blackburnian Warbler	3	6	0	2			2	0							0	1

Appendix 4 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Pine Warbler													1	0		
Palm Warbler	1	6	0	1	1	0										
Bay-breasted Warbler	4	4	1	2	0	3			0	5						
Black-and-white Warbler	4	5	7	5	4	13	5	5	8	5	5	4	8	5	4	6
American Redstart	1	20	0	3	2	5	1	1			1	3	0	1	2	0
Ovenbird	17	25	19	14	21	36	20	17	9	19	23	19	10	11	2	13
Northern Waterthrush					0	2									0	1
Connecticut Warbler					3	0									0	1
Mourning Warbler	5	2	2	1	1	0			1	0	5	0				
Common Yellowthroat	2	10	10	9	5	7	10	5	6	7	11	16	13	12	4	10
Canada Warbler	1	2	1	1			3	3					0	1	1	1
Scarlet Tanager	2	0			0	2	1	1	0	2	1	3				

Appendix 4 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Rose-breasted Grosbeak	0	4	9	4	2	4	5	5	5	5	4	1	4	0	0	1
Indigo Bunting	0	1	3	4	2	0	15	0	2	16	3	2	1	4	1	0
Rufous-sided Towhee	1	3	4	2	4	0	11	2	1	0	2	1	2	0	3	1
Chipping Sparrow	4	0	5	1	2	1	12	3	30	2	0	14	2	3	4	3
Vesper Sparrow											1	0	1	1	1	0
Song Sparrow	3	8	13	4	8	4	18	6	1	0	2	1	5	2	6	2
Lincoln's Sparrow	0	1									1	0				
Swamp Sparrow	3	8	4	5	2	9	8	5	2	13	3	3	1	5	0	5
White-throated Sparrow	49	24	76	27	42	20	80	20	31	12	28	23	30	12	19	7
Dark-eyed Junco	0	1	0	1	3	0	3	0	3	0					2	0
Red-winged blackbird			1	0	0	1										
Common Grackle			1	0	1	1	1	0			0	1				

Appendix 4 (continued)

	1986		1987		1988		1989		1990		1991		1992		1993	
Species	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Purple Finch			8	0	3	0	3	0			2	0			1	0
White-winged Crossbill			8	1			29	7					4	0		
Pine Siskin			2	0							0	1				
American Goldfinch	8	9	8	8	5	7	16	5	5	3	13	12	19	28	5	6
Evening Grosbeak					0	4	1	1			1	1	3	0	0	3
Unidentified non-passerine	94	101	124	101	91	100	80	69	50	61	228	141	123	106	180	176
Unidentified sparrow			8	1	1	0			1	2	0	1	2	7	6	6
Unidentified thrush			1	0	0	1					1	2	0	1		
Unidentified woodpecker	2	9	11	12	7	10	7	7	1	5	7	16	8	17	3	6
Unidentified vireo													0	2	0	1
Unidentified warbler			1	0	3	0					6	9			9	7
Unidentified duck	0	4			1	0										

Appendix 4 (continued)

Species	1986		1987		1988		1989		1990		1991		1992		1993	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Unidentified raptor							1	0								
Unidentified passerine											0	2			0	3
Total individuals	682	978	1129	936	882	882	1122	838	635	741	1001	901	741	737	666	739
Total number species	63	59	69	64	63	67	70	59	52	55	61	61	57	57	53	51

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Appendix 5. Presentations, publications, and manuscripts based on work conducted as part of the ELF monitoring program.

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Presentations

Hanowski, J.M., and G.J. Niemi. 1987. Statistical perspectives and experimental design in bird censusing. American Ornithologists Union; San Francisco State University; August 1987.

Hanowski, J.M., and G.J. Niemi. 1987. Assessing the effects of an extremely low frequency (ELF) antenna system on bird species and communities in northern Wisconsin and Michigan. Lake Superior Biological Conference; University of Minnesota-Duluth; September 1987.

Blake, J.G., J.M. Hanowski, G.J. Niemi, and P.T. Collins. 1988. Seasonal and annual variation in the influence of time of day on bird censuses. Cooper Ornithological Society, Asilomar, California; March 1988.

Blake, J.G., G.J. Niemi, and J.M. Hanowski. 1989. Annual variation in bird populations: some consequences of scale of analysis. Cooper Ornithological Society, Moscow, Idaho; June 1989.

Blake, J.G., G.J. Niemi, and J.M. Hanowski. 1989. Drought and annual variation in bird populations: effects of migratory strategy and breeding habitat. Symposium on Ecology and Conservation of Neotropical Migrant Landbirds, Woods Hole, Massachusetts; December 1989.

Hanowski, J. M., J. G. Blake, and G. J. Niemi. 1990. Seasonal bird distribution patterns along habitat edges in northern Wisconsin. Lake Superior Biological Conference, Ashland, Wisconsin; September 1990.

Hanowski, J. M., G. J. Niemi, J. G. Blake, and P. T. Collins. 1990. Effects of extremely low frequency electromagnetic fields on bird species and communities.

- Annual Review of Research on Biological Effects of 50/60 Hz Electric and Magnetic Fields, Denver, Colorado; November 1990.
- 52nd Midwest Fish and Wildlife Conference, Minneapolis, Minnesota; December 1990.
- 20th ~~XX~~ Congressus Internationalis Ornithologicus, Christchurch, New Zealand; December 1990.

Collins, P.T. 1990. Birds and invertebrates in northern Wisconsin forests: Are they related?

- University of Minnesota, Duluth; May 1991.
- American Ornithologists' Union; McGill University, Montreal; September 1991.

Blake, J. G., J. M. Hanowski, and G. J. Niemi. 1992. Annual variation in bird populations of mixed conifer-northern hardwood forests. American Ornithologists Union, Ames, Iowa; June 1992.

Blake, J. G. 1992. Temporal and spatial variation in migrant bird populations. Department of Ecology, Ethology, and Evolution, University of Illinois; April 1992.

Helle, P.J. 1992. Bird community dynamics in boreal forests. IUFRO Centennial Meeting (International Union of Forestry Research Organizations), Berlin, Germany; September 1992.

Hanowski, J. M. 1993. Seasonal abundance and composition of forest bird communities adjacent to a right-of-way in northern forests USA. Fifth International Symposium on environmental concerns in rights-of-way management. Montreal, Canada; September 1993.

Helle, P.J. 1993. Bird community response to forest fragmentation: A holarctic view. International Union of Game Biologists. Halifax, Nova Scotia; August 1993.

Publications

Hanowski, J. M., J.G. Blake, and G. J. Niemi. In press. Seasonal abundance and composition of forest bird communities adjacent to a right-of-way in northern forests USA. Proceedings from Fifth International Symposium on environmental concerns in rights-of-way management. Montreal, Canada.

Blake, J. G. J. M. Hanowski, G. J. Niemi, and P. T. Collins. Annual variation in bird populations of mixed conifer-northern hardwoods forests. Condor: in press.

Hanowski, J. M., J. G. Blake, G. J. Niemi, and P. T. Collins. 1993. Effects of extremely low frequency electromagnetic fields on breeding and migrating birds. American Midland Naturalist 129:96-115.

Collins, P. T. 1992. Length-biomass relationship for terrestrial gastropods and Oligochaetes. American Midland Naturalist 128:404-406.

Blake, J.G., G.J. Niemi, and J.M. Hanowski. 1992. Drought and annual variation in bird populations. pgs. 419-430. In J. Hagan and D. W. Johnston, eds., Ecology and conservation of neotropical landbird migrants. Smithsonian Institution Press, Washington, DC.

Blake, J.G., J.M. Hanowski, G.J. Niemi, and P.T. Collins. 1991. Hourly variation in transect counts of birds. Ornis Fennica 68:139-147.

Collins, P.T. 1991. Relationships between invertebrate biomass and bird abundance in northern Wisconsin forests. MS thesis, University of Minnesota.

Hanowski, J.M., G.J. Niemi, and J.G. Blake. 1990. Statistical perspectives and experimental design in counting birds with line transects. Condor 92:328-337.

Manuscripts (in review)

Helle, P. and G. Niemi. Bird community dynamics in boreal forests. Submitted to: R. M. DeGraaf (ed.), Wildlife conservation in forested landscapes. Elsevier Publishing.

Manuscripts (in preparation)

Collins, P.T., G.J. Niemi, J.G. Blake, and J.M. Hanowski. Lateral distance distribution patterns for northern forest birds.

Hanowski, J. M., J. G. Blake, and G. J. Niemi. Effects of extremely low frequency electromagnetic fields on breeding and migrating birds.

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Appendix 6. Grand mean (all years treatment and reference) and coefficient of variation for bird community, individual species, and guilds. Values were used to calculate the power of a univariate repeated measures ANOVA.

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Appendix 6. Grand mean (all years treatment and reference) and coefficient of variation for bird community, individual species, and guilds. Values were used to calculate the power of a univariate repeated measures ANOVA.

	Spring		Breeding		Fall	
Total individuals	21.04	15	38.48	6	20.69	12
Total no. species	9.86	15	16.62	6	8.69	15
Ruffed Grouse	0.31	156	0.28	243	0.30	260
American Woodcock					0.10	296
Yellow-bellied Sapsucker	0.61	126	0.54	119	0.28	209
Downy Woodpecker	0.14	287	0.22	238	0.28	182
Hairy Woodpecker	0.09	366	0.15	247	0.22	213
Northern Flicker	0.44	145	0.40	162	0.51	136
Eastern Wood-Pewee			0.40	130	0.39	147
Yellow-bellied Flycatcher			0.49	114		
Alder Flycatcher			0.19	182		
Least Flycatcher	0.54	214	0.99	129		
Great Crested Flycatcher	0.09	332	0.45	132		
Eastern Kingbird			0.09	348		
Tree Swallow	0.10	527				
Gray Jay			0.11	375	0.22	266
Blue Jay	0.71	134	0.89	108	1.16	88
Common Raven			0.13	305		
Black-capped Chickadee	1.39	88	1.80	82	3.32	53
Red-breasted Nuthatch	0.45	152	0.60	117	1.36	76
White-breasted Nuthatch			0.11	345	0.21	218
Brown Creeper	0.33	213	0.37	167	0.57	145
Winter Wren	0.61	111	0.76	84	0.21	237
Sedge Wren			0.08	341		
Golden-crowned Kinglet	0.99	111	1.33	77	1.33	102
Ruby-crowned Kinglet	0.44	198	0.09	394	0.09	509

Appendix 6 (continued)

	Spring		Breeding		Fall	
Veery			0.64	109		
Hermit Thrush	0.80	113	1.99	51	0.69	110
American Robin	0.81	108	0.79	100	0.45	158
Brown Thrasher			0.05	448		
Cedar Waxwing			0.46	202	0.67	157
Solitary Vireo	0.12	308	0.18	249		
Red-eyed Vireo	0.09	400	2.84	38	0.90	102
Golden-winged Warbler			0.16	232		
Nashville Warbler	2.35	72	3.10	39	0.28	276
Northern Parula	0.12	304	0.23	191		
Chestnut-sided Warbler	0.17	292	1.14	84		
Yellow-rumped Warbler	1.21	94	0.69	105	0.18	363
Black-throated Green Warbler	1.10	93	1.84	50	0.20	253
Blackburnian Warbler			0.25	189		
Black-and-white Warbler	0.39	158	0.63	107	0.15	278
Ovenbird	1.41	87	4.27	25	0.46	142
Mourning Warbler			0.45	133		
Common Yellowthroat			0.53	103	0.15	268
Canada Warbler			0.12	311		
Scarlet Tanager			0.38	140		
Rose-breasted Grosbeak	0.36	186	0.86	91	0.08	392
Indigo Bunting			0.51	124	0.08	450
Rufous-sided Towhee	0.07	376	0.14	258		
Chipping Sparrow	0.35	195	0.45	132	0.10	435
Song Sparrow	0.23	218	0.38	141	0.11	355
Swamp Sparrow	0.22	203	0.28	136	0.06	485
White-throated Sparrow	1.42	87	1.42	67	0.63	148

Appendix 6 (continued)

	Spring		Breeding		Fall	
Dark-eyed Junco	0.08	407				
Red-winged blackbird	0.24	234	0.21	231		
Common Grackle	0.12	278	0.14	343		
Brown-headed Cowbird	0.20	250	0.11	300		
Purple Finch	0.32	188	0.11	302		
American Goldfinch			0.14	275	0.20	242
Evening Grosbeak	0.11	491				

Appendix 6 (continued)

	Spring		Breeding		Fall	
Nests						
Ground	7.56	30	14.67	10	3.10	50
Canopy or canopy vegetation	6.77	28	11.86	14	6.38	33
Subcanopy or shrub	1.95	86	5.81	32	0.97	111
Cavity, hole or bank	4.07	41	5.14	33	7.32	29
Ledge or platform	0.02	872	0.01	822	0.01	897
Nest parasite	0.20	250	0.11	300		
Habitat						
Deciduous	6.01	33	15.06	12	8.10	24
Coniferous	3.87	46	3.97	38	3.38	50
Mixed decid-conifers	2.66	56	5.17	23	1.56	71
Early successional	1.75	82	3.45	44	0.90	129
Fields & meadows	1.97	66	2.67	50	1.45	81
Lowland coniferous	3.34	52	4.90	29	0.99	121
Migration						
Permanent	3.64	46	4.99	37	8.15	26
Short-distance	9.95	21	10.94	16	5.84	35
Long-distance	6.83	43	21.46	8	3.58	49
Forage						
Ground invertebrates	2.22	58	4.07	30	1.85	68
Foliage insects	10.59	24	21.66	8	7.76	28
Flycatchers	0.61	179	2.71	48	0.71	122
Bark insects	1.49	75	2.14	57	2.94	51

Appendix 7. Electromagnetic field intensities measured at bird transects from 1984 to 1993.

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TABLE 7-1. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10C1-2	-	<	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C1-3	-	-	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C2-1	-	<	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C2-2	-	<	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C5-2	-	<	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C5-3	-	<	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C12-1	-	-	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C12-2	-	-	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C13-1	-	-	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10C13-2	-	-	<	<	<	<	<	<[d]	<[d]	<[d]	<[d]
10T1-1	-	<	<	<	<	<	<0.001	<[b]	<[c]	<[b]	<[c]
10T1-3	-	-	<	<	<	<	<	<[b]	<[b]	<[b]	<[b]
10T1-4	-	-	-	<	<	<	<	<[b]	<[c]	<[b]	<[c]
10T1-5	-	-	-	<	<	<	<0.001	<[b]	<[c]	<[b]	<[b]

TABLE 7-1. 60 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Bird Species and Communities Studies
Michigan Transects (page 2 of 2)

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10T2-1	-	<0.001	<	<	<	<	<	<[c]	<[b]	<[b]	<[b]
10T2-2	-	-	-	<	<	<	<	<[b]	<[b]	<[b]	<[b]
10T2-4	-	-	<	<	<	0.008	#	<[b]	<[b]	<[b]	<[b]
10T3-1	-	<	<	<	<	<	<	#	<[b]	<[b]	<[b]
10T3-2	-	<	<	<	<	<	<	#	<[c]	<[b]	<[b]
10T3-3	-	-	-	<	<	/	<0.001	#	<[c]	<[b]	<[b]
10T4-1	-	<	<	<	<	<	<	#	<[c]	<[b]	<[b]
10T4-3	-	-	-	<	<	<	<	#	<[c]	/	<[b]
10T11-1	-	-	<	<	<	/	<0.001	#	<[b]	<[b]	<[b]
10T11-2	-	-	<	<	0.011	/	<0.001	#	<[b]	<[b]	<[c]

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 ampere current.

- = measurement point not established.
= measurement precluded by antenna operation.
< = measurement estimated <0.001 V/m based on earth electric field.
/ = measurement not taken.

**TABLE 7-2. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)**

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10C1-2	-	0.62	0.106, 0.141	0.101	0.059	00.20	0.073	0.27[d]	0.105[d]	0.098[d]	0.099[d]
10C1-3	-	-	0.26, 0.27	0.055	0.21	0.32	0.72	0.079[d]	0.78[d]	0.50[d]	0.41[d]
10C2-1	-	0.98	0.138	0.041	0.038	0.087	0.080	0.076[d]	0.076[d]	0.031[d]	0.088[d]
10C2-2	-	0.35	0.21	0.055	0.048	0.047	0.069	0.076[d]	0.057[d]	0.045[d]	0.064[d]
10C5-2	-	0.35	0.45	0.193	0.116	0.23	0.053	0.050[d]	0.037[d]	0.44[d]	0.89[d]
10C5-3	-	0.111	0.23	0.25	0.103	0.126	0.050	0.073[d]	0.160[d]	0.27[d]	0.46[d]
10C12-1	-	-	0.194, 0.28	0.058	0.256	0.98	1.19	0.22[d]	1.32[d]	0.65[d]	0.46[d]
10C12-2	-	-	0.106, 0.141	0.101	0.059	0.20	0.073	0.27[d]	0.105[d]	0.098[d]	0.099[d]
10C13-1	-	-	0.34, 0.52	0.30	0.40	0.37	0.78	0.099[d]	0.156[d]	0.70[d]	1.10[d]
10C13-2	-	-	0.143, 0.31	0.139	0.157	0.121	0.039	0.074[d]	0.212[d]	0.30[d]	0.33[d]
10T1-1	-	0.076	0.061	0.034	0.099	0.21	0.077	0.039[b]	0.038[c]	0.056[b]	0.23[c]
10T1-3	-	-	0.38	0.120	0.20	0.51	#	0.106[b]	0.092[b]	0.036[b]	0.102[b]
10T1-4	-	-	-	0.111	0.085	0.30	0.076	0.029[b]	0.040[c]	0.032[b]	0.21[c]
10T1-5	-	-	-	0.040	0.052	0.116	0.052	0.021[b]	0.023[c]	0.030[b]	0.033[b]

TABLE 7-2. 60 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Bird Species and Communities Studies
Michigan Transects (page 2 of 2)

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10T2-1	-	0.42	0.194	0.050	0.058	0.23	0.034	0.130[c]	0.123[b]	0.081[b]	0.035[b]
10T2-2	-	-	-	0.058	0.052	0.24	0.023	0.028[b]	0.090[b]	0.046[b]	0.038[b]
10T2-4	-	-	0.158	0.054	0.029	0.166	0.164	0.013[b]	0.093[b]	0.038[b]	0.065[b]
10T3-1	-	0.30	0.23	0.145	0.164	0.070	#	#	0.148[b]	0.170[b]	0.148[b]
10T3-2	-	0.26	0.117	0.069	0.103	0.075	#	#	0.173[c]	0.091[b]	0.107[b]
10T3-3	-	-	-	0.094	0.120	0.132	0.32	#	0.39[c]	0.105[b]	0.133[b]
10T4-1	-	0.29	0.132	0.129	0.093	0.087	#	#	0.20[c]	0.076[b]	0.198[b]
10T4-3	-	-	-	0.112	0.22	0.166	0.087	#	0.21[c]	/	0.159[b]
10T11-1	-	-	0.23	0.172	0.106	0.095	0.25	#	0.145[b]	0.116[b]	0.150[b]
10T11-2	-	-	0.26, 0.50	0.58	0.45	0.196	0.21	#	0.34[b]	0.22[b]	0.32[c]

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 ampere current.

- = measurement point not established.
= measurement precluded by antenna operation.
/ = measurement not taken.

TABLE 7-3. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10C1-2	-	0.001	0.001	<0.001	<0.001	0.001	0.001	0.001[d]	0.001[d]	0.001[d]	<0.001[d]
10C1-3	-	-	0.001, 0.003	<0.001	0.003	0.002	0.007	0.002[d]	0.010[d]	0.004[d]	0.004[d]
10C2-1	-	0.005	0.004	<0.001	<0.001	<0.001	0.001	0.001[d]	0.001[d]	<0.001[d]	0.001[d]
10C2-2	-	0.003	0.003	<0.001	0.001	0.001	0.001	0.001[d]	0.001[d]	<0.001[d]	0.001[d]
10C5-2	-	0.008	0.009	0.006	0.005	0.006	0.002	0.001[d]	0.008[d]	0.014[d]	0.021[d]
10C5-3	-	0.001	0.002	0.002	0.001	0.001	0.001	0.001[d]	0.002[d]	0.002[d]	0.003[d]
10C12-1	-	-	0.001, 0.003	0.002	0.003	0.011	0.009	0.001[d]	0.014[d]	0.006[d]	0.006[d]
10C12-2	-	-	0.001	<0.001	<0.001	0.001	0.001	0.001[d]	0.001[d]	0.001[d]	<0.001[d]
10C13-1	-	-	0.007, 0.010	0.007	0.005	0.003	0.009	0.003[d]	0.011[d]	0.017[d]	0.026[d]
10C13-2	-	-	0.001, <0.001	0.001	0.001	0.001	0.001	0.001[d]	0.001[d]	0.002[d]	0.002[d]
10T1-1	-	0.006	0.004	0.002	0.005	0.016	0.005	0.002[b]	0.002[c]	0.003[b]	0.015[c]
10T1-3	-	-	0.002	0.003	0.005	0.017	#	0.003[b]	0.005[b]	0.002[b]	0.004[b]
10T1-4	-	-	-	0.003	0.003	0.009	0.002	0.001[b]	0.002[c]	0.002[b]	0.007[c]
10T1-5	-	-	-	0.003	0.016	0.012	0.003	0.001[b]	0.002[c]	0.002[b]	0.002[b]

TABLE 7-3. 60 Hz MAGNETIC FLUX DENSITIES (mG)
Bird Species and Communities Studies
Michigan Transects (page 2 of 2)

Site No., Meas. Pt.	1983[a]	1984[a]	1985[a]	1986[b]	1987[c]	1988[c]	1989[d]	1990	1991	1992	1993
10T2-1	-	0.002	0.002	0.003	0.005	0.012	0.001	0.007[c]	0.009[b]	0.003[b]	0.001[b]
10T2-2	-	-	-	<0.001	0.002	0.008	0.001	0.001[b]	0.006[b]	0.002[b]	<0.001[b]
10T2-4	-	-	0.001	0.002	0.001	0.004	0.001	<0.001[b]	0.004[b]	0.001[b]	<0.001[b]
10T3-1	-	0.001	0.001	0.006	0.003	0.004	#	#	0.003[b]	0.002[b]	0.004[b]
10T3-2	-	0.001	<0.001	0.008	0.005	0.004	#	#	0.012[c]	0.003[b]	0.011[b]
10T3-3	-	-	-	0.012	0.007	0.017	0.010	#	0.030[c]	0.001[b]	0.010[b]
10T4-1	-	0.001	<0.001	0.002	0.002	0.003	#	#	0.004[C]	0.001[b]	0.002[b]
10T4-3	-	-	-	0.001	0.003	0.004	0.002	#	0.006[c]	/	0.003[b]
10T11-1	-	-	<0.001	0.006	0.006	0.003	0.003	#	0.003[b]	0.002[b]	0.004[b]
10T11-2	-	-	0.001, <0.001	0.008	0.005	0.004	<0.001	#	0.006[b]	0.003[b]	0.010[c]

a = antennas not constructed.
b = antennas off, grounded at transmitter.
c = antennas off, connected to transmitter.
d = antennas on, 150 ampere current.

- = measurement point not established.
= measurement precluded by antenna operation.
/ = measurement not taken.

TABLE 7-4. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10C1-2	<	<	<	•	<	<	<	<	<	<	<	<	<
10C1-3	<	<	<	•	<	<	<	<	<	<	<	<	<
10C2-1	<	<	<	•	<	<	<	<	<	<	<	<	<
10C2-2	<	<	<	•	<	<	<	<	<	<	<	<	<
10C5-2	<	<	<	•	<	<	<	<	<	<	<	<	<
10C5-3	<	<	<	•	<	<	<	<	<	<	<	<	<
10C12-1	<	<	<	•	<	<	<	<	<	<	<	<	<
10C12-2	<	<	<	•	<	<	<	<	<	<	<	<	<
10C13-1	<	<	<	•	<	<	<	<	<	<	<	<	<
10C13-2	<	<	<	•	<	<	<	<	<	<	<	<	<
10T1-1	<	<	<	•	0.005	<	0.022	<	0.036	0.036	0.037	0.032	0.036
10T1-3	0.002	<	<	•	0.007	<	0.038	<0.001	0.068	0.081	0.084	0.055	0.076
10T1-4	<	<	<	•	0.004	<	0.024	<	0.036	0.040	0.033	0.026	0.054
10T1-5	<	<	<	•	0.003	<	0.010	<	0.022	0.020	0.022	0.016	0.027

TABLE 7-4. 76 Hz AIR ELECTRIC FIELD INTENSITIES (V/m) Bird Species and Communities Studies Michigan Transects (page 2 of 2)

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10T2-1	0.002	<	<	*	0.006	<	0.033	<0.001	0.059	0.088	0.072	0.072	0.104
10T2-2	0.002	<	<	*	0.007	<	0.047	0.003	0.062	0.062	0.069	0.036	0.056
10T2-4	0.002	<	<	*	0.007	<	0.028	0.007	0.062	0.060	0.075	0.039	0.065
10T3-1	0.004	<	<	*	0.005	0.003	/	/	0.040	0.050	0.050	/	0.040
10T3-2	0.004	<	0.001	0.002	0.006	0.003	/	/	0.071	0.070	0.067	/	0.044
10T3-3	0.005	<	0.017	0.028	0.005	0.009	/	/	0.170	0.130	0.125	/	0.080
10T4-1	0.002	<	0.003	0.005	0.003	0.006	/	/	0.049	0.051	0.067	0.075	0.051
10T4-3	<	<	0.003	0.005	0.001	0.008	/	/	0.078	0.062	0.072	/	0.053
10T11-1	<	<	<	*	0.004	0.002	/	/	0.051	0.053	0.064	0.063	0.053
10T11-2	<	<	<	*	0.038	0.009	/	/	0.108	0.27	0.185	1.32	0.141

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW - southern EW antenna element.
B = NS + EW antennas, standard phasing

EX = extrapolated data.
* = data cannot be extrapolated.
< = measurement estimated <0.001 V/m based on earth electric field
/ = measurement not taken.

**TABLE 7-5. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)**

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10C1-2	0.004	0.003	0.004	0.007	0.015	0.012	0.074	0.058	0.153	0.31	0.139	0.158	0.158
10C1-3	0.013	0.004	0.002	0.003	0.049	0.011	0.26	0.060	0.41	0.44	0.50	0.55	0.70
10C2-1	0.017	0.002	0.007	0.012	0.073	0.021	0.30	0.095	0.78	0.70	0.64	0.62	0.63
10C2-2	0.011	0.003	0.007	0.012	0.037	0.020	0.176	0.100	0.33	0.43	0.30	0.40	0.33
10C5-2	0.001	0.003	0.007	0.012	0.014	0.023	0.073	0.119	0.26	0.28	0.21	0.179	0.23
10C5-3	0.005	0.003	0.009	0.015	0.017	0.027	0.091	0.143	0.30	0.28	0.24	0.29	0.29
10C12-1	0.028	0.010	0.011	0.018	0.068	0.028	0.36	0.140	1.37	0.76	0.90	0.94	1.02
10C12-2	0.004	0.003	0.004	0.007	0.015	0.012	0.074	0.058	0.153	0.31	0.139	0.158	0.158
10C13-1	0.024	0.027	0.104	0.173	0.057	0.24	0.32	1.39	4.8	4.2	3.3	3.9	4.3
10C13-2	0.024	0.023	0.098	0.163	0.089	0.29	0.34	1.07	2.1	2.7	2.4	2.7	2.5
10T1-1	0.85	0.028	0.008	0.013	2.8	0.015	13.0	0.115	42	32	41	38	29
10T1-3	2.2	0.068	0.077	0.128	7.1	0.147	33	0.86	74	82	77	76	78
10T1-4	0.96	0.030	0.031	0.052	4.1	0.087	19.8	0.46	35	42	40	43	40
10T1-5	0.65	0.020	0.006	0.010	2.3	0.015	10.9	0.098	20	19.7	19.0	21	19

TABLE 7-5. 76 Hz EARTH ELECTRIC FIELD INTENSITIES (mV/m)
Bird Species and Communities Studies
Michigan Transects (page 2 of 2)

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10T2-1	1.42	0.043	0.077	0.128	5.3	0.25	31	1.05	48	44	76	83	95
10T2-2	1.69	0.056	0.107	0.178	7.0	0.34	33	1.77	53	65	67	63	62
10T2-4	0.59	0.056	0.158	0.26	5.0	0.49	26	2.6	79	71	57	74	71
10T3-1	0.82	0.23	0.60	1.00	4.9	2.1	26	10.1	47	46	47	46	48
10T3-2	1.24	0.133	1.05	1.75	5.4	2.7	21	31	61	66	76	78	75
10T3-3	1.36	0.34	3.6	6.0	4.8	7.5	43	54	111	105	105	112	110
10T4-1	0.88	0.137	1.58	2.6	2.4	4.8	14.5	19.3	62	61	58	54	59
10T4-3	0.46	0.139	1.92	3.2	1.30	8.1	5.4	39	68	66	67	/	57
10T11-1	0.67	0.27	0.59	0.98	3.9	1.97	17.6	8.9	47	49	47	52	49
10T11-2	1.38	0.93	0.44	0.73	7.3	2.9	32	12.6	105	86	72	77	94

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW - southern EW antenna element.
B = NS + EW antennas, standard phasing

EX = extrapolated data.
/ = measurement not taken.

TABLE 7-6. 76 Hz MAGNETIC FLUX DENSITIES (mG)
Bird Species and Communities Studies
Michigan Transects (page 1 of 2)

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10C1-2	<0.001	<0.001	<0.001	•	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	0.001
10C1-3	<0.001	<0.001	<0.001	•	<0.001	<0.001	0.002	<0.001	0.003	0.003	0.001	0.003	0.003
10C2-1	<0.001	<0.001	<0.001	•	0.001	0.001	0.005	0.002	0.009	0.009	0.007	0.006	0.007
10C2-2	<0.001	<0.001	<0.001	•	0.001	<0.001	0.003	0.002	0.005	0.005	0.005	0.005	0.005
10C5-2	<0.001	<0.001	<0.001	•	<0.001	0.001	0.001	0.002	0.005	0.005	0.005	0.005	0.005
10C5-3	<0.001	<0.001	<0.001	•	<0.001	<0.001	0.001	0.001	0.003	0.003	0.003	0.003	0.003
10C12-1	<0.001	<0.001	<0.001	•	<0.001	<0.001	0.002	0.001	0.004	0.004	0.002	0.005	0.005
10C12-2	<0.001	<0.001	<0.001	•	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	0.001
10C13-1	<0.001	<0.001	<0.001	•	0.001	0.002	0.002	0.009	0.066	0.066	0.047	0.066	0.059
10C13-2	<0.001	<0.001	<0.001	•	<0.001	0.001	0.002	0.006	0.015	0.015	0.014	0.013	0.014
10T1-1	0.044	0.001	<0.001	•	0.179	0.001	0.84	0.005	1.87	1.63	1.60	1.77	1.68
10T1-3	0.047	0.001	0.007	0.012	0.176	0.001	0.84	0.010	1.70	1.62	1.64	1.68	1.57
10T1-4	0.026	0.001	0.001	0.002	0.103	0.002	0.49	0.014	1.02	0.95	0.91	0.94	0.92
10T1-5	0.034	0.001	0.001	0.002	0.49	0.002	0.61	0.008	1.31	1.20	1.19	1.22	1.16

**TABLE 7-6. 76 Hz MAGENETIC FLUX DENSITIES (mG)
Bird Species and Communities Studies
Michigan Transects (page 2 of 2)**

	1986				1987		1988		1989	1990	1991	1992	1993
Site No., Meas. Pt.	NS 4 A	NEW 6 A	SEW 6 A	SEW 10 A, EX	NS 15 A	EW 15 A	NS 75 A	EW 75 A	B 150 A	B 150 A	B 150 A	B 150 A	B 150 A
10T2-1	0.066	0.002	0.001	0.002	0.25	0.001	1.21	0.010	2.5	2.4	2.3	2.4	2.3
10T2-2	0.043	0.001	0.001	0.002	0.165	0.002	0.80	0.010	1.61	1.54	1.55	1.60	1.53
10T2-4	0.026	0.001	0.001	0.002	0.097	0.002	0.46	0.005	0.97	0.92	0.91	0.91	0.91
10T3-1	0.029	0.003	0.007	0.012	0.188	0.015	0.96	0.078	1.89	1.87	1.85	1.94	1.90
10T3-2	0.081	0.002	0.013	0.022	0.29	0.031	1.61	0.161	2.9	2.9	2.8	3.0	2.9
10T3-3	0.116	0.40	0.58	0.97	0.196	0.89	1.11	7.7	15.0	14.3	14.0	15.0	14.2
10T4-1	0.025	0.001	0.081	0.135	0.038	0.191	0.20	1.00	1.92	1.89	1.90	2.0	1.94
10T4-3	0.025	0.001	0.119	0.198	0.011	0.32	0.051	1.42	2.9	2.7	2.6	/	2.8
10T11-1	0.033	0.002	0.006	0.010	0.24	0.015	1.09	0.072	2.3	2.3	2.0	2.2	2.2
10T11-2	0.042	0.003	0.003	0.005	0.31	0.006	1.42	0.033	2.9	2.8	2.8	3.0	2.8

NS = north-south antenna.
EW = east-west antenna.
NEW = northern EW antenna element.
SEW - southern EW antenna element.
B = NS + EW antennas, standard phasing

EX = extrapolated data.
* = data cannot be extrapolated.
/ = measurement not taken.

TABLE 7-7. 1993 PAIRED SITE EM FIELD INTENSITY RATIOS
Bird Species and Communities Studies

Compared	Air Electric Field				Earth Electric Field				Magnetic Flux Density			
Transects	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
10T1/10C1	27	27	27	1.00	120	126	46	0.080 - 2.3	310	112	230	0.50 - 15.0
10T1/10C2	27	27	27	1.00	30	126	220	0.38 - 3.6	131	112	920	2.0 - 15.0
10T1/10C5	27	27	27	1.00	66	126	21	0.037 - 0.50	184	112	44	0.095 - 5.0
10T1/10C12	27	27	27	1.00	18.6	126	41	0.072 - 2.3	184	112	153	0.33 - 15.0
10T1/10C13	27	27	27	1.00	4.4	126	17.3	0.030 - 0.70	15.6	112	35	0.077 - 7.5
10T2/10C1	56	56	56	1.00	390	1090	151	0.085 - 0.66	300	910	230	0.25 - 1.00
10T2/10C2	56	56	56	1.00	98	1090	700	0.40 - 1.02	130	910	910	1.00
10T2/10C5	56	56	56	1.00	210	1090	70	0.039 - 0.141	182	910	43	0.048 - 0.33
10T2/10C12	56	56	56	1.00	61	1090	135	0.076 - 0.66	182	910	152	0.167 - 1.00
10T2/10C13	56	56	56	1.00	14.4	1090	56	0.032 - 0.20	15.4	910	35	0.038 - 0.50
10T3/10C1	40	40	40	1.00	300	320	117	0.26 - 1.49	630	260	480	1.00 - 11.0
10T3/10C2	40	40	40	1.00	76	320	550	1.22 - 2.3	270	260	1900	4.0 - 11.0
10T3/10C5	40	40	40	1.00	166	320	54	0.120 - 0.32	380	260	90	0.190 - 3.7
10T3/10C12	40	40	40	1.00	47	320	104	0.23 - 1.49	380	260	320	0.67 - 11.0
10T3/10C13	40	40	40	1.00	11.2	320	44	0.097 - 0.45	32	260	73	0.154 - 5.5
10T4/10C1	51	53	51	1.00	360	300	139	0.39 - 2.0	650	930	490	0.50 - 3.0
10T4/10C2	51	53	51	1.00	90	300	650	1.81 - 3.1	280	930	1940	2.0 - 3.0
10T4/10C5	51	53	51	1.00	200	300	64	0.179 - 0.43	390	930	92	0.095 - 1.00
10T4/10C12	51	53	51	1.00	56	300	124	0.35 - 2.0	390	930	320	0.33 - 3.0
10T4/10C13	51	53	51	1.00	13.3	300	52	0.145 - 0.60	33	930	75	0.077 - 1.50
10T11/10C1	53	53	53	1.00	310	290	120	0.37 - 3.2	730	280	550	1.00 - 10.0
10T11/10C2	53	53	53	1.00	78	290	560	1.70 - 5.0	310	280	2200	4.0 - 10.0
10T11/10C5	53	53	53	1.00	169	290	55	0.169 - 0.70	440	280	105	0.190 - 3.3
10T11/10C12	53	53	53	1.00	48	290	107	0.33 - 3.2	440	280	370	0.67 - 10.0
10T11/10C13	53	53	53	1.00	11.4	290	45	0.136 - 0.97	37	280	85	0.154 - 5.0

R1: T(76)/C(76) — T(76) = ELF Communications System EM fields at the treatment sites.
R2: T(76)/T(60) — C(76) = ELF Communications System EM fields at the control sites.
R3: T(76)/C(60) — T(60) = ambient EM fields at the treatment site.
R4: T(60)/C(60) — C(60) = ambient EM fields at the control site.